S. HRG. 99-210

INDOOR AIR POLLUTION

HEARING

BEFORE THE

COMMITTEE ON ENVIRONMENT AND PUBLIC WORKS UNITED STATES SENATE

NINETY-NINTH CONGRESS

FIRST SESSION

ON

S. 1198

A BILL TO ESTABLISH IN THE ENVIRONMENTAL PROTECTION AGENCY A PROGRAM OF RESEARCH ON INDOOR AIR QUALITY, AND FOR OTHER PURPOSES

AUGUST 5, 1985—AUGUSTA, ME

Printed for the use of the Committee on Environment and Public Works

U.S. GOVERNMENT PRINTING OFFICE

52-630 O WASHINGTON : 1985

52-630 O—85——1

S321-33

COMMITTEE ON ENVIRONMENT AND PUBLIC WORKS

ROBERT T. STAFFORD, Vermont, *Chairman*

JOHN H. CHAFEE, Rhode Island	LLOYD BENTSEN, Texas
ALAN K. SIMPSON, Wyoming	QUENTIN N. BURDICK, North Dakota
JAMES ABDNOR, South Dakota	GARY HART, Colorado
STEVE SYMMS, Idaho	DANIEL PATRICK MOYNIHAN, New York
GORDON J. HUMPHREY, New Hampshire	GEORGE J. MITCHELL, Maine
PETE V. DOMENICI, New Mexico	MAX BAUCUS, Montana
DAVE DURENBERGER, Minnesota	FRANK R. LAUTENBERG, New Jersey

BAILEY GUARD, *Staff Director*
LEE O. FULLER, *Minority Staff Director*

CONTENTS

	Page
Mitchell, Hon. George J., U.S. Senator from the State of Maine, opening statement of	1

WITNESSES

Burk, Marshall, director of environmental health, Maine Lung Association	23
Hess, Charles professor of physics, University of Maine	10
Written statement	48
Hillier, Charles, research director, Maine State Employees Association	25
Hutchinson, Keith	20
LaCombe, Eleanor	18
Petit, Micheal, commissioner, Maine Department of Human Services	5
Written statement	30
Rand, Peter, director, department of research, Maine Medical Center	13
Scudder, Jean, Maine Audubon Society	26
Written statement	57
Shibles, Lee, Southern Maine Vocational and Technical Institute	22
Warren, Henry, commissioner, Maine Department of Environmental Protection	3

ADDITIONAL MATERIAL

Air pollution in your home	52
Kerry, John M., director, office of energy resources, State of Maine, statement of	62
Radon in water and air, health risks and control measures	36
S. 1198	63

INDOOR AIR POLLUTION

MONDAY, AUGUST 5, 1985

U.S. SENATE,
COMMITTEE ON ENVIRONMENT AND PUBLIC WORKS,
Augusta, ME.

The committee met, at 10 a.m., in the appropriations room of the State Capitol Building, Augusta, ME, Hon. George J. Mitchell presiding.

OPENING STATEMENT OF HON. GEORGE J. MITCHELL, U.S. SENATOR FROM THE STATE OF MAINE

Senator MITCHELL. Good morning ladies and gentlemen. I would like to welcome you to this hearing of the U.S. Senate Committee on Environment and Public Works. I regret that Senator Stafford, the chairman of the committee, is unable to be here due to another pressing commitment.

Today's hearing will focus on the problem of indoor air pollution and exposure to radon gas.

Since enactment of the Clean Air Act 15 years ago, we have made great progress in the protection of air quality and the control of air pollution. More active attention is needed to such issues as acidity in rainfall and other precipitation. But on a daily basis, the vast majority of Americans today breathe cleaner air than they did 15 years ago.

The Clean Air Act, of course, is directed to the quality of air outdoors. The majority of Americans, however, spend most of the day indoors. And we have done little to assess the kinds of pollutants that may exist indoors or to determine the health effects of exposure to such pollutants.

Such information as we have today results from research into specific pollutants. Thus we have some data on the effects of such pollutants as formaldehyde, asbestos, and radon gas. And there is substantial and growing evidence that these and other pollutants which are often concentrated indoors pose a significant health threat.

The EPA has documented an impressive range of health effects from indoor air pollutants. Lung cancer results from exposure to radon gas, asbestos, volatile organic chemicals, and passive exposure to tobacco smoke. Respiratory illness can be caused by exposure to formaldehyde, nitrogen dioxide, and allergens. Skin and eye irritation can be caused by sulfer dioxide, carbon monoxide, and nitrogen oxide.

Any doubt about the seriousness of indoor air pollution can be remedied by facts. The facts about one single pollutant—radon gas—are both dramatic and frightening.

Radon is a naturally occurring element found in soils and granite rock. The EPA estimates that exposure to radon results in between 5,000 to 20,000 lung cancer deaths per year throughout the country. As we will hear later in today's hearing, radon gas is a particular problem in Maine. In addition, this health threat may grow as people continue to insulate their homes and reduce the amount of air exchange in winter as a means of conserving home heating costs.

Despite clear evidence of the serious health effects of indoor air pollution, the EPA has done little to develop a comprehensive and coordinated program of research to address the problem. The Agency says that it does not have explicit statutory authority to regulate air pollution indoors and therefore should not research it.

The Agency also proposes to eliminate the small amount of funding for work in this area next year. The EPA says that research into this problem is a "low Agency priority when compared to other Agency resource needs." Existing funding of about $2 million is small compared to the $236 million to implement the Clean Air Act and $325 million for research and development.

In order to assure adequate attention to the problem of indoor air pollution, I recently introduced the Indoor Air Quality Research Act of 1985. The bill includes three major provisions.

First, the EPA Administrator is to establish a research program to analyze data, coordinate the related activities of other Agencies, and assess possible approaches to control indoor air pollution problems.

Second, EPA is to submit to Congress within 2 years a report summarizing the state of knowledge about this problem, needed further research, and potential actions to mitigate health effects.

Finally, funding of $3 million is authorized to be appropriated for the EPA for the 1986 and 1987 fiscal years. I am very pleased to report that, just last week, the Senate Appropriations Committee approved an amendment to the appropriations bill for the Environmental Protection Agency which provides $2 million to support research on indoor air quality in 1986.

This decision to appropriate funds for indoor air research will assure that the EPA will be able to take the lead in developing a coordinated indoor air quality research program and will be able to implement the Indoor Air Quality Research Act when it is passed.

I want to stress that this legislation does not authorize the EPA Administrator to carry out any regulatory program or any activity other than research, development, demonstration and related activities.

A comprehensive approach to assessing the nature of the problem, such as my bill proposes, is a modest but important first step in dealing with the problem before it reaches unmanagable proportions.

Once we have a research program in place and a clear statement of the problem, we can develop proposals for control of indoor air pollution which are tailored to the specific characteristics of the problem.

We are fortunate to have a number of extremely qualified witnesses from around the State to address this important problem.

Commissioner Petit, of the Department of Human Services and Commissioner Warren of the Department of Environmental Protection will form our first panel.

The second panel is made up of Dr. Charles Hess of the University of Maine at Orono and Dr. Peter Rand of the Maine Medical Center. Dr. Hess is a nationally recognized expert on radon gas. Dr. Rand is conducting research into the health effects of radon.

The third panel includes Dr. Keith Hutchinson of Belfast and Ms. Eleanor Lacombe of New Gloucester. Dr. Hutchinson and Ms. Lacombe both discovered high radon levels in their homes and took steps to address the problem.

The final panel includes Mr. Lee Shibles of Southern Maine Vocational Technical Institute, Mr. Marshall Burk of the Maine Lung Association, Mr. Charles Hillier of the Maine State Employees Association, and Mr. Jeff Thaler of Maine Audubon. They will review the work of their organizations on this problem.

Again, I would like to thank everyone for coming today. At this point, we will proceed to the first panel.

Mr. Petit and Mr. Warren, we welcome you. You may proceed in any order that you wish, gentlemen.

STATEMENT OF HENRY WARREN, COMMISSIONER, MAINE DEPARTMENT OF ENVIRONMENTAL PROTECTION

Mr. WARREN. I guess I'll begin, Senator. My name is Henry Warren and I'm commissioner of the department of environmental protection, which by the way has no authority under State law to deal with indoor air quality. For that reason, we're very much in support of the bill which you are proposing to draw some attention to and get some information and data on that important subject.

We work closely with the U.S. Environmental Protection Agency, which has made some progress in air quality and the control of ambient air pollution. But recognition that the indoor air environment is not an exact reflection of outdoor conditions is of relatively recent concern.

As you have noted, Americans spend 80 to 90 percent of their time indoors. In addition, people who are particularly susceptible to air pollution, the sick, the disabled, the very young, and the very old spend a majority of their time indoors. Available information suggests that elevated concentrations of some air contaminants are routinely encountered in indoor environments. In fact, for certain pollutant levels, the air inside some homes may exceed the standards that are set for outdoor concentrations.

In particular, there are concerns in the northern States that efforts to conserve fuel and energy by tightening up houses and buildings may result in even higher levels of indoor air pollution. Therefore, it is important that our assessment of the overall health effects attributable to air pollution consider the impact both of ambient and of indoor sources.

As you are aware, the Interagency Committee on Indoor Air Quality was founded in December 1983 and is comprised of 16 Federal agencies. The committee has developed a comprehensive re-

search strategy on indoor air quality which was completed on January 1, 1985. The strategy sets the following task:

First, the identification of air pollutant sources indoors and factors affecting human exposure.

Second, the characterization of indoor air quality.

Third, the determination of the health effects of indoor air pollution.

Fourth, the determination of optimal control and mitigation techniques.

And finally, the development and conduct of national multiple studies.

I see that your air quality bill is consistent with this gravity. It gives EPA the necessary incentive to move the strategy into the implementation stage. The bill provides a focus on direction and perhaps more important it sets a priority for the EPA to act. I do have a few concerns, however.

First, as we have experienced with the acid rain issue with which you're familiar, very familiar, research has often been substituted for action. While this bill established a research program to study the indoor air pollution problem, it does one other very important thing; it requires EPA to complete that research within 2 years and report its findings to Congress.

I encourage you not to let the problems of indoor air pollution be caught up in the morass of research, rather than action. We cannot afford to let it become just another report.

Second, I would recommend that the advisory committee, which is proposed in your bill, be comprised of the four cochairs of the existing Interagency Committee on Indoor Air Quality. Those include the Environmental Protection Agency, the Department of Energy, the Department of Health and Human Services, and the Consumer Products Safety Commission.

The experience which this group has should be utilized. Lastly, I would like to relate my experiences with the control of hazardous air pollutants. Section 112 of the Clean Air Act which establishes the national emissions standards for hazardous air pollutants has been sorely deficient. The process for listing hazardous air pollution companies is very complex.

That the EPA has to date issued standards for only six pollutants is evidence of that fact at least. This has forced each State to proceed on its own initiative which has resulted in as many different approaches to the control of hazardous pollutants as there are States. Similarly, indoor air pollution could fall into this same situation, unless Federal oversight is given. Indoor air pollution is a national issue and it deserves that Federal attention.

If I can digress for just a moment, there were two thoughts that occurred to me on my drive up this morning from Cape Elizabeth which, as you know, has an ozone monitor and gets listed there as the highest ozone impact town in the State.

Because of that monitoring program and the ozone level alerts which we issue as a result of high levels when they occur, we advise people with lung impairments and sensitivity to poor air quality to stay indoors, and to close their windows at this time. It would be ironic, although not amusing, if in doing so, they ex-

changed impacts from outdoor pollutants for those resulting from indoor air pollution.

The second thought is, your bill, while it doesn't say so explicitly, the implication is that there's an emphasis on indoor air quality within the home and perhaps offices or other public buildings. I notice little mention of indoor air quality in the industrial setting. While Federal law gives OSHA responsibility in this area, my experience suggests that research of the type you are proposing should not ignore that setting.

At the minimum we ought to insure that existing programs are working to protect the employee who may be exposed to toxic air pollutants and particulate matter in the workplace. In fact, we have recently issued a permit to a generator of electricity from wood which will be located in Jonesboro, the water supply comes from undeground in the very heavily granite area and radon measurements are very high. So even in the industrial situation, radon could be a problem for employees.

In summary, your bill provides a means to implement the Interagency Committee on Indoor Air Quality strategy. Requested funding will supplement funds already allocated by the various Federal agencies to address other aspects of indoor air pollution. Once we have a clear statement of the problem, which should result from this research, then a tailored controlled strategy to solve the indoor air problem can be provided.

Therefore, I strongly endorse the passage of this bill and would offer any assistance I can in reaching that goal.

Senator MITCHELL. Thank you, very much, Commissioner Warren. Commissioner Petit.

STATEMENT OF MICHAEL PETIT, COMMISSIONER, MAINE DEPARTMENT OF HUMAN SERVICES

Mr. PETIT. Senator Mitchell, thank you for the opportunity to make this presentation here this morning. One of the disadvantages of going second when you're on a panel with your peers is that they get the great lines you had worked in to your own remarks first, so I'll try to concentrate on testimony that is slightly different than that which was presented by Commissioner Warren.

To begin with I would say we certainly agree with your overview of the problem and the department of human services would echo many of the same sentiments presented by Commissioner Warren.

In addition to radon, which we have been deeply involved with in the last few years, I have some documents, that I will leave with you and your staff, that explains our involvement in this area and exactly what the dimensions of the problems are in Maine. One area that is not frequently mentioned, but which comes forward in our investigations of this problem in the State is the issue of tobacco smoke as a major indoor pollutant and perhaps the single greatest problem we have with indoor pollution in the State of Maine at the present time.

You should be aware that the legislation did adopt a law in the last legislative session that requires every employer in the State to adopt a smoking policy. The Department of Human Services on September 3 will be implementating a no-smoking policy in each of

the 35 buildings that will limit smoking to a single designated site in each of its office spaces.

If for some reason that policy is difficult to enforce at the end of the 60-day period, the department is prepared to go to a complete ban on smoking in its 35 buildings, which is a reflection, I believe on the seriousness of which we are viewing this problem at the present time.

It has been submitted that there are some 5,000 deaths in the United States related to secondhand smoke, sidestream smoke, and in Maine that would be about 25 deaths per year.

We also know that since people spend about 90 percent of their time indoors, it is essential to come to an understanding as to exactly how serious indoor air contamination is. As Commissioner Warren pointed out, this is especially true to those that are most vulnerable, the elderly, infants, expected mothers, and those who are chronically ill.

In addition to a serious health threat, we believe there are some huge costs to our national health care system and some of the numbers suggest annual costs to the public of somewhere between $15 and $100 billion a year. The department of human services using its Federal prevention block grant as a means for investigating the possible link between radon and cancer, we have a number of people working on that now and the appendix that I'll be giving you describes what we're doing.

I have with me Dr. William Nasso who is a director of the bureau of health and Donald Haxie who is a director of our health engineering program, they can respond to any technical questions that you may have. In the last couple of months we have requested an increase for assistance in this area. The department has found it necessary to reassign a chemical engineer and a field technician to start developing a State response to air pollution concerns.

We've had difficulties in some of our State buildings in the last 2 or 3 years, including the department of transportation building, the department of human services building in Caribou in part related to contamination of soils by gasoline, which have infiltrated the building and have created many problems there. At this point there are four things that we have identified as being needed from the Federal Government:

First, it's our belief that Federal activities on indoor air environment have been limited, sporadic, and underfunded, and what we would like to see are measures that address the four following consideration.

One is appropriate air standards. There should be separate indoor standards for evaluating potential risk. At the present time the standards that exist are based upon outdoor air pollution contaminants and are based on a 40-hour workweek at a worksite; for example, for healthy adults we believe that these standards are inadequate to address residential or industrial settings, especially by those who are vulnerable.

Second, and we believe your bill would aid in this process, simple testing methods are needed. Developing and standardizing simple methods for testing pollutants in the air is much needed. Present methodology involves expensive equipment or lab procedures and is extremely labor intensive.

What we would like to see is a development of a passive testing device which can be mailed to people's homes to allow them to perform their own sampling and in some cases their own analysis. We also need pollutant projection models. The State/Federal system we feel cannot do this by themselves in developing models to assist in projecting which pollutants might be present in the home.

Since indoor pollutants can range from particulates to radiation to several dozen organic compounds, it is important to have an idea of what pollutants should be expected to be found in the home before conducting a field investigation for providing the home with a test kit.

Finally, the whole question of public information. We had a discussion this morning in my office about how many homebuilders and architects, and homeowner's in the next year would want to be constructing homes in this State that rest in an area with high radon or are even aware of the fact that there are precautionary measures that they can take in this area.

Developing easily understood health risk information for the general public describing the risk, typical background, indoor air levels, and recommending proven corrective measures also essential. Again it's not possible, in our opinion, for the State, at least this State, by itself to address this problem individually.

In summary, we would like to compliment your leadership for introducing S. 1198. We strongly support its intent and agree more research is needed if we are to adequately administer an indoor air pollution program. It is our opinion that the State is not able to do this independently.

Senator MITCHELL. Thank you, very much, I'd like to ask a couple of questions, first, to Commissioner Warren. You mentioned toxic pollutants in your remarks and that subject is receiving increasing attention now primarily with respect to its presence in the outdoor air. Obviously the threat indoors is as great or greater.

First, do you believe that the regulation of toxic pollutants outdoors and indoors should be coordinated in some fashion; and do you have any suggestions as to how that might best be done? In other words, we have a separate outdoor air act now and probably after this study is completed, we're going to deal with the problem of a regulatory program for indoor air. We have a pollutant that's common to both, toxic pollutants as distinguished from radon; do you have any suggestions how we can best accomplish that?

Mr. WARREN. Senator, I have given a lot of thought to that, and the one area I have difficulty understanding is how that would be included in the standard-setting process which Mr. Petit mentioned. I want to give it some thought and speak to my staff about it.

Senator MITCHELL. If you'd like to supplement your answer with a statement, that would be fine.

Mr. WARREN. With regard to the administrative side of it, I believe my department and the department of human services have always had a close relationship which involves both ongoing staff efforts, as well as periodic meetings, shared research, shared personnel, at times, and shared money with regard to common issues of public health and certainly air quality issues. Toxic pollutants,

in recent months, have been high on that list and so I believe a mechanism at the State level already exists to manage that.

I think your legislation, as you look ahead, will have a much more difficult job getting similar cooperation and coordination at the Federal level in terms of sharing even within the EPA itself for which, historically in my experience, does not always talk to itself and share information.

In this case, the kind of toxic materials you're talking about impact not only the air quality, but water quality and hazardous materials through Superfund and others. They are often the same materials and sometimes the disposal of one in one median results in their creating pollution problems in another. As I said, I think that would be much more difficult in the State of Maine where we're fairly close and small, but I will give some thought to the standard setting issue.

Senator MITCHELL. Commissioner Petit, in your remarks, you mentioned you had some experience with radon. Could you briefly summarize what the experience was within your agency, how the problem arose, and how you dealt with it?

Mr. PETIT. We've not had a problem with radon within our own buildings, if that's what you mean. The problems we've had in our own building have been related basically to gasoline fumes, contaminated soil surrounding the building, and all of the synthetic contaminants that were introduced in the new building. Those things together combined to create a serious problem with our office workers and we have spent many thousands of dollars to rectify that in the last year.

Senator MITCHELL. Have you had any exposure to the problem of radon whether in your buildings or not?

Mr. PETIT. Yes, and I'd ask Don Haxie to respond to that. Don, would you speak to that?

Mr. HAXIE. The radon problem goes back into the 1950's here in the State of Maine. There was a ground water well found over in Raymond and very shortly after that discovery, the existing standard for radon in drinking water disappeared from the national standards. The National Bureau of Standards produced the standard at that time.

We basically went for a number of years thinking the problem was essentially related to radon in the water itself. About 5 or 6 years ago, maybe longer than that, nearer 10 years ago now, some work done at the Federal level when EPA began to take a look that the fact that radon is basically released from water very much like carbon dioxide from soda. EPA began to take a look at exposure through breathing radon back into the lungs and began to take a look at some does projections and related to the work done on the uranium mines.

Also at that time, the department took a look at existing cancer data; we knew by that time what areas in the State had reasonably high levels. As a result of the preliminary epidemiology work, we decided we did not have enough data. We contacted the University of Maine.

I think there may be a speaker later. Dr. Hess, who will be talking about that, looking at what geological denominations in the State of Maine we could relate radon to. And that may lead to

some additional work at the University of Maine in developing removal techniques. As a result of some of Dr. Hess' publications, I think radon has come into national focus. Now we believe that the radon problem in structures in Main is basically due to airborne exposures which are complicated by tightening our homes up for energy purposes.

The department has passive protections that we can send out to the homes that can measure radon levels in the air. Unfortunately, it takes about 3 months to make that determination. We also send out test kits to the homeowner's so they can take a sample and send it back to the laboratory.

We're in the position of now telling people what we know about the health risk and I tell that with tongue in cheek, depending on who you talk to you get a different response for a potential risk. We did call on the University of Maine to produce a publication which is called Radon In Water and Air and that's what we're providing you with. (See p. 36.) What we see for the potential risk at this point in time, basically highlights what I've told you.

Senator MITCHELL. Thank you very much, Mr. Haxie. I want to ask one other question of both of you and ask that perhaps you think about it and respond in writing at your convenience. It's a broader more general question.

You both run important and, Commissioner, in this case a very large agency that have extensive dealings with a Federal agency and which implement Federal laws, and so you both have, in your own areas, a lot of experience in the development and implementation of Federal programs from the beginning, that is, assessment of the problem, evaluation of ways of dealing with the problem, enactment of regulatory program, and implementation of regulatory program.

I would ask you to give some thought to, and out of your own experience, submit some of your own views as to how best we can deal with this problem and avoid some of the problems or difficulties that have arisen in your own experience in dealing with other Federal regulatory programs. Every State official with whom I've talked here in Maine and elsewhere has generally a catalog of difficulties that they have encountered in dealing with Federal agencies.

They vary, of course, depending on the subject matters, but since we are beginning a process which will very likely culminate in a Federal regulatory program at some point in the future, should the study demonstrate such a need? I'd like to try to avoid some of the problems that may have arisen in other areas and it seems to me you're unique, by virtue of your experience, in a position to help do that.

Mr. PETIT. Without responding in great detail, I would say that the most important underpinning is an aggressive executive branch posture at the Federal level that is sincerely committed to addressing the problems, not with strong laws, advanced commitments by the Congress in any one of 50 problem areas we can deal with. Unless the executive branch is willing to strongly assert that particular issue with the States, we have a great deal of difficulty dealing with the executive branch of the administration.

[Mr. Petit supplied the following:]

STATE OF MAINE,
DEPARTMENT OF HUMAN SERVICES,
Augusta, ME, August 13, 1985.

Hon. GEORGE MITCHELL,
U.S. Senator, Committee on Environmental and Public Works, Russell Senate Office Building, Washington, DC.

Re Indoor Air Quality Act of 1975.

DEAR SENATOR MITCHELL: At your hearing on August 5 you asked for the Department's thoughts about the Federal role in implementing a national indoor air quality program. We believe that to be successful such a program must be implemented and made operational at the municipal, county and state level. The role of the Federal Government should consist primarily of providing research assistance in establishing guidelines, providing training and, perhaps most importantly, providing federal funding to encourage and enable the states to address these problems in a timely fashion. Block grants would be helpful because they would allow the states to tailor programs to specific needs, needs which undoubtedly vary from one state to the next.

We do not believe that a federal enforcement program, similar to the Clean Air Act or the Clean Water Act is necessarily desirable. In many cases the Department provides consultation and allows people to decide on what corrective measures to take based on their income and particular circumstances. For the last 25 or 30 years the Department has operated a similar program in the area of private drinking water. For example, the state identifies problems with individual wells and makes recommendations for corrections, but leaves the final decision of what corrective action to take up to the individual homeowner. This approach simply allows a more flexible response and has been well received by Maine citizens. We would be happy to provide you with specific details if you wish.

Sincerely,

MICHAEL R. PETIT,
Commissioner.

Mr. WARREN. If I could add one additional thought which occurred to me and that is that it seems to me that dealing with indoor air pollution you have, if not unique, certainly different than most pollution problems with which the Federal Government has involved itself. Local and State action has identified this problem and clearly, that's not a program that can be administered at the Federal level.

I think to the extent that your research focus is strictly technical, it might always focus on the administrative question which will be somewhat different and in the long run much more important in many ways than the technical side of it.

Senator MITCHELL. Thank you both, very much. Your testimony has been very helpful. The next panel will consist of Dr. Charles Hess of the department of physics at the University of Maine at Orono; and Dr. Peter Rand, a director of the department of research of the Maine Medical Center of Portland, ME.

Welcome, gentlemen. Dr. Hess, do you want to proceed first? Fine.

STATEMENT OF CHARLES HESS, PROFESSOR OF PHYSICS, UNIVERSITY OF MAINE

Dr. HESS. I'd like to show a few slides of the randon problem as I've investigated it over the past few years.

Senator MITCHELL. Go ahead.

Dr. HESS. The topic of indoor air pollution as relates to radon started about 10 years ago for me. I've given you written testimony about this, but I just want to highlight a few of the points in that

testimony with some slides and also to give an opportunity perhaps for people to ask questions about specifics.

In the first place, I should point out that in Maine there are really two sources of radon that are major sources. One of them is the soil itself, soil and rock underneath the house. The other one is the well water. The radon gas that's in the soil can get in the house through the cracks in the basement, through openings, subholes, drain pipes, and so on that come out of the basement.

The water entry point brings the radon right up into the first floor of the house or into the basement through water use. Radon can come out of the water and get into the air of the house. The same effect would occur from either type of radon, the water radon or soil gas radon.

It's already known that radon causes problems in poorly ventilated mines. This slide is a graph of the lung cancer access for uranium miners who happens to work underground and have soil gas radon or rock radon to live with when they are working.

The linear graph for lung cancer versus the total exposure to radon, it turns out, has some points on it that are in the vicinity of radon levels that we find in homes in Maine. In other words, some of the houses in Maine have high enough radon levels so they are on this line. We don't have to project it. You can actually measure the radon in the house and you can find what the risk is using the uranium miner risk.

However, this point about whether or not miners and homeowners are subject to the same risk is something that is still being researched right now.

Senator MITCHELL. In other words, the point you're making is that the exposure of miners is generally at a far more intense level than anyone would expect to experience in their daily lives.

Dr. HESS. That's right.

Senator MITCHELL. So you can't be certain that the data based upon miners exposure proves anything with respect to exposure of a typical nonminer?

Dr. HESS. The health physics community generally believes that exposures are the same for miners and nonminers and that when you talk about a certain amount of dose to an individual, the same risk will be for a miner as for a nonminer. In light of that fact, we can calculate the risk that individuals have in homes and because that lies on the curve that has been measured for miners, this leads us to believe that there should be a risk for lung cancer in the general population.

We have here a map showing the water measurements that we made over several years and it's shown as dots. The size of the dots are proportional to the average water levels in these homes that were measured.

Senator MITCHELL. The average water levels or radon levels?

Dr. HESS. Radon and water concentration. The red zones are grid areas, orange and yellow are very nearly the same geological type as the granite. The black dots, which are the high-concentration dots, are clustered in the areas which have been the grid geology and that fact has made it possible for us to calculate a lung cancer versus radon and water risk. We did it by counties and we used lung cancer data from the Atlas of Cancer Mortality published by

the National Cancer Institute and we plotted the average radon concentration in the 16 counties of Maine.

What we found are shown in these graphs right here of lung cancer risk versus radon and picocuries per liter. Each county is a dot on that plot. The top data is for males and the lower data there is for females. The correlations in the case of the females are significant so that only 3 chances in 1,000, but that's just a randon occurrence. This is considered publishable information. It's been published in journals and so on.

Senator MITCHELL. Why is it so much lower for females, if I read that chart?

Dr. HESS. It's one of the indoor pollutant charts that causes the difference between male and female. The data is based on the women who died in the 50-to-68 sector so these are women who were born around 1900. A majority of these women did not smoke and you see the different curve between women and men. It represents the effect of smoking.

The highest point on this curve right here turns out is in Sagadahoc County and that's been tested by the Center for Disease Control. It's believed there it was asbestos exposure that produced this very high point for men. I would say that, generally, the male scatter here is probably caused by smoking and by occupational exposures to carcinogens.

Senator MITCHELL. What's the lowest county there?

Dr. HESS. This one right here is Aroostook County.

Senator MITCHELL. No; there's one lower than that for males.

Dr. HESS. I don't remember. I'd have to look that up.

Senator MITCHELL. All right.

Dr. HESS. My last slide is a list of what I think are research needs that are important things to consider for the future and I have included this list in my testimony. I just wanted to mention a couple of these that I think are very important for the EPA to deal with. I think a national field study is needed to give a context for the radon problem. One of our big problems in Maine has been that we have data and we can compare other data to our States where there happen to be studies.

But we don't have a nationwide study of radon in private homes and small facilities. Rural water, turns out, has more radon in it than the city water because rural water tends to come from a small well and the need is for a survey that includes rural samples all over the United States so that we can get a good context for what we have found in Maine.

The other really important thing I think is the national study for radon and air. Someone always asks me what does this particular radon value mean? I have to put that in some context. If I had radon values for the whole United States that I could refer to, I could then put it in a context as to whether it was high or low relative to the whole United States. I think that's an extremely important thing to find out just to get some perspective of what the actual readings we've gotten in Maine mean.

The other thing we can do is identify other radon areas that haven't been discovered because the radon measurements that occurred already usually occurred because of some other purpose, either because of mining or something like that. There hasn't been

a dedicated effort to find all of the hot spots in the country. A good field study of the entire United States would show that.

There are other research interests that I have listed on that slide that I would be glad to talk about if anyone is interested. That concludes my testimony.

Senator MITCHELL. Thank you, very much, Dr. Hess. Why don't you take a seat. I may have some more questions for you, but why don't we hear first from Dr. Rand.

STATEMENT OF PETER RAND, DIRECTOR, DEPARTMENT OF RESEARCH, MAINE MEDICAL CENTER

Dr. RAND. Senator Mitchell, and members of the Environmental Public Works Committee. My name is Peter W. Rand and I'm director of the research department at the Maine Medical Center in Portland, ME; and principal investigator of and epidemiologic case-control study investigating the health effects of the high levels of the radon gas in Maine homes. I've been asked today to describe the health effects of radon in general and then summarize our research.

Radon is a chemically inert, and radioactive gas which occurs in the environment as a decay to protect the radon which is a national constituent of certain types of bedrock and soil. Thus, radon is released in the home environment either directly from underlying soils or indirectly by escaping from water drawn from wells drilled in bedrock. With the emitting of strongly ionizing alpha particles radon undergoes further radioactive decay to form a series of short-lived heavy metal daughter elements, three of which are also alpha emitters.

The primary route of human exposure to these radioactive elements is by inhalation of the lung. Although radon itself contributes some radiation, the more important contribution is from its solid daughter products which attach themselves either directly or indirectly via dust particles to the lining of the bronchial tubes where they remain in the focal source of alpha emission.

Because of their mass, alpha particles can penetrate no more than seven one-hundredths of a millimeter, but this distance is sufficient to expose the underlying layer of basal cells, which is the origin of most forms of bronchiogenic carcinoma. Despite their lack of penetration, alpha particles are intensely ionizing and have high bilogical effectiveness to other forms of radiation.

The primary concern, therefore, is the high levels of radon in the domestic environment may cause lung cancer. Virtually all of the direct associations and risk projections relative to radon's health effects, however, have come from studies done on miners. Because radon levels are frequently much higher in mines; because working conditions, the degree of exertion in total years of exposure are different; and because the mining population does not include women, considerable caution must be exercised in translating the risk projected from mining studies to the general population.

Nevertheless, evidence that radon in mines causes lung cancer is overwhelming. As early as 1516 it was observed up to one-half of the European bedrock miners were dying of respiratory disease subsequently shown to be bronchiogenic carcinoma. More recent

studies involving uranium, iron, fluorspar, and other bedrock miners of the United States, Czechoslovakia, Canada, Scandianivia, and elsewhere have demonstrated direct relationships between radon dose and lung cancer incidents.

A latency from the first exposure to the onset of lung cancer of from 7 to 50 years, and both increased risks, as well as shorter induction times with increasing age at first exposure. Although earlier studies indicated that cigarette smode multiplies the incidence of lung cancer among radon-exposed miners, other research has shown that the effect may be less than synergistic.

Evidence for an association between radon and lung cancer in the domestic environment is much less clear cut. An increased presence of abnormal chromosones has been observed in humans exposed to high radon and well water in Finland, and to high air radon in Austrian health spas. Swedish workers have measured a higher incidence of lung cancer in districts with high radon soils, and here in Maine our collaborator, Dr. C. Thomas Hess, has shown the positive linear relationships between projected county radon levels amd mortality from lung cancer and all cancers combined. Despite these relationships, because water and air radon levels very widely within small geographic areas, final evidence for a causal relationship must be based on a comparison of individual exposures over an extended period of time.

Since radon is swallowed in water and since it quite frequently diffuses into the bloodstream from the lungs, it quite possibly may play a role in the genesis of other forms of cancer. Because exposure by these routes is much less than that experienced by the bronchial epitelium. This is a difficult hypothesis to prove epidemiologically. Some reports, however, have suggested relationships between high radon and cancer of the skin, stomach, panceas, breast, bone, and blood cells.

Our own research has compared home, air, and water radon exposures among three groups; those with lung cancer, those with all other forms of cancer, and those with no cancer. It's been carried out since 1982 as a collaborative effort where Dr. Hess, the University of Maine Physics Department, Dr. Gregory Bogdan of the Maine Department of Human Services—Environmental Health Unit, and Miss Melanie Lanctot of the Maine Geological Survey. To focus on people at risk our initial approach has been limited to individuals on drilled wells for at least 10 years. All subjects have answered a questionnaire related to home construction and water supply, smoking, occupational exposure, and medical history. To date we have studied 450 homes, and while we do not have a large enough population in all groups to make valid statistical comparisons, we have developed some useful exposure information. For example, 1 out of 6 of our subjects' houses have water radon above 10,000 picocuries and 1 out of 10 exceeds 20,000 picocuries per liter. The average level for water radon across the country is well below 1,000 picocuries. No maximum safety number limit has been set for radon and water; in fact, the information needed to set such a standard would be based on a study such as ours.

With respect to radon in home air, 1 out of 4 of the homes in our study exceeds 3 picocuries per liter, which is a limt recommended by the USEPA, and 1 in 10 have levels above 5 picocuries. Using

the average level of 8 picocuries in this last group we can calculate using the admittedly continuous risk estimates developed from mining studies, that 30 years of such exposure would produce from 6 to 60 extra lung cancers per 1,000 individuals during their lifetimes.

From this study we have determined on statistical grounds that a case control study to include all new female lung cancer cases in Maine and New Hampshire over the next 3 years would be feasible to determine the effect of radon lung cancer. Under the auspices of the U.S. Environmental Protection Agency, we are now proceeding with the planning for such a study which should commence before the end of the year.

That's the end of my prepared testimony, Senator Mitchell. I might just digress how this relates to the bill you have proposed by going down through the items of the program requirement. The first of which is the research development concerning the identification, characterization, and monitoring of sources and I'll hold my comments to radon. We are getting a view of what the problem is in Maine and in the process of that we're discovering that what we thought was the problem related to water radon, it is really to a great extent a problem from air radon, it is really to a great extent a problem from air radon, radon coming up from the soil, rather than from the water.

I'm not saying that water is an important source, but there is a high proportion of our cases that very high radon in their air that is out of proportion one would expect from the water.

Another problem is that around the country, there is increasing evidence of very high exposures to radon that really has to be looked at. I would mention this briefly the problem in Bordertown, PA, where levels of radon are 100, or many times 100 times as high as we have found here in Maine. This is so far a relatively localized situation in maybe 150 homes or so, but having experiences like that certainly calls for nationwide efforts to describe what the real geographic radon exposures.

Going on, you're calling for research and development into building types. Mention has been made of the danger of superinsulated buildings. This I think really does have to be looked into with very good scientific approach. While it is true that by reducing the air exchange rate in these buildings, one certainly would expect to have higher degrees of radon and it may be a fact that the superinsulated buildings to extend our reducing the stack effect which is the bringing in of radon from the soil into the home and thereby maybe buildings that have open cellars without cement on their floors or open foundation poses more of a problem than the houses that are superinsulated.

This research is being done into this right now, but I think a great deal has to be done so I think we know what the effect of insulated buildings is. And that information is very important in the determination of how to mitigate against home air radon, just how to go about the faults that may be in the building, to get rid of radon, which, of course, has enormous economic impact, but not only to the homeowners, but to the industry, as well.

You also call for an instrument for indoor air quality data collection. We have found in our study that there is a great need ex-

pressed to us by our subjects to have much more information than is currently available to them about where the radon in their home is coming from, is it coming from the sump pump in the cellar? Is it coming from granite in the foundation? Is it coming from the water? It's a slow process now, an expensive one to determine where air radon is coming from, unless you have very specialized devices. A common device is called a Track Etch cup which is to be left in the home for 2 or 3 months and costs $25 apiece for each one of them.

A method must be found so that one can go into a house and very quickly within a week perhaps discover exactly where the radon is coming from. And, of course, this information should then be followed through with whatever mitigation methods would be called for in the basis of that.

And, finally, you called for a research and development to control technology. In Pennsylvania, I understand that some of the initial technologies to control air radon some of the homes affected there run as much as $50,000.

These are additional efforts, of course, which can be brought down, but much information has to be learned through research about how best and the least expensive to control radon once it is in the home. So on the basis of that, obviously I am highly in favor of the bill that you have proposed and fully recommend it and I appreciate the opportunity to provide the information and stand ready for any requests you might have.

Senator MITCHELL. Thank you, Dr. Rand. Let me ask both of you, do we need to establish a national standard for exposure to radon in the air and drinking water?

Dr. HESS. Maybe I could reply. I feel at this time if we were to form a national standard based on what information we have right now, we could be in the very bad position of finding out after the standard was passed that the problem was either very much smaller than we thought or very much larger than we thought because there isn't clear information for the whole United States. It seems to me that it would be very premature to have a standard based on the information we have right now.

Senator MITCHELL. That would be the very reason for the study, in other words, to gather the data upon which to base any standards more accurately?

Dr. RAND. It may not be quite clear as to whether the exposure to a low level of radon for a long period of time is the same thing as intermittent exposure to extraordinarily high levels of radon. One of the things that Tom has found in his research here is that in homes that have high radon levels in their water, the radon emanates very rapidly from the water, particularly once it's heated.

So if you find yourself in a high radon water home, and you are in the habit of taking 15-minute hot showers, the level of radon may go to hundreds of picocuries per liter within that shower while you're there. We just don't know whether that exposure means the same thing as having a home with 5 picocuries per liter over 30 years. So a lot of work has to be done regarding the dose response of radon.

Senator MITCHELL. Does the radon enter in through breathing?

Dr. HESS. Yes.

Senator MITCHELL. That's emitted from the water and breathed in?

Dr. HESS. Yes.

Senator MITCHELL. Are either of you familiar with any experience or programs in other countries dealing with this problem; and if so, are there any that may hold some relevance to our situation in this matter?

Dr. RAND. I'm familiar with the way in which the problem is handled in Sweden. There is a particular type of bedrock called alanite and homes are built on it there just as we do here in Maine and that allows radon to come into the homes. It's such a problem over there that they are developing performance standards for the building of the homes if they are on high radon ground.

So if they know that a home is going to be built on high radon ground, the contractor is required to lay cement a certain number of inches thick and to put pipes under the home to ventilate the air that's under it, or to put stacks in to ventilate it out from the basement through the roof.

Senator MITCHELL. Are you aware whether or not that's a national requirement?

Dr. HESS. I think it is. I'm not going to say that it isn't.

Most of the houses in Sweden are financed by a Federal FAJ type of plan. And so when they have a national standard, it affects the FAJ plan. They are equivalent to the FHA and that in effect makes it a national program, although you can't get money from a bank just like here and build a house.

Senator MITCHELL. In you remarks, Dr. Hess, you talked about the possible difference between super-insulation or those that don't have basements, that leads me to another question. Obviously the desire to have the proper air exchange and ventilation to minimize radon is a valuable objective. At the same time insulation of homes is a valuable objective.

There's a proper policy basis for encouraging people to insulate. Do either of you have any thoughts on how those two valid objectives can be accommodated, that is, what we might do to accomplish both more effective insulation of homes to minimize home hearing costs, a very real problem particularly in a State with cold winters and low per capita incomes, along with the problem of trying to minimize the possible adverse effect of radon exposures?

Dr. HESS. The point is that insulation per se does not produce the radon problem. Adding insulation to a house merely would cut down on the heat loss through the ceiling and walls. The secondary thing that's done after you put the insulation in is to seal the house. That's the step which worsens the radon and air pollution. The sealing up of the house to prevent air from coming in from outside leads to stagnation of the air inside the house, it isn't diluted by outside air.

So it's quite possible to have a very well-insulated house, but not airtight. The two things don't have to come together. If you're willing to take the penalties of heating the extra air that comes in for ventilation purposes and consider that an essential part of house heating, and then plan to make the house thermally sound by putting insulation in the walls to prevent heat loss through the walls

and windows and so on, its seems to me that you can get both of the desired effects, namely, and less expensive heating bill, but at the same time a healthy environment inside the house.

Senator MITCHELL. Did you want to add to that?

Dr. RAND. Simply that as I mentioned the whole problem of insulation, sealing, subfloor ventilation, and relative to the type of home construction there's an area which needs a tremendous amount of research to that we know exactly how.

Senator MITCHELL. Dr. Rand, I was interested in your statement where you said that some reports suggested relationships of high radon and cancer of the skin, stomach, pancreas, breast, bone, and blood cells. Most of the attention has been focused on lung cancer. Do you think we ought to attempt to focus attention or at least part of our effort in the study should go toward areas other than lung cancer that is among what you suggested here?

Dr. RAND. I think it's an area that should be looked at in two ways. One by comparison of perhaps using the geographical approach used in radon seeing whether there are higher incidences of certain of those cancers in areas where there is high radon. But that has to be done in States where good cancer information is available.

Also, I think we need to do some human studies to identify how radon is distributed in the body. As I explained, it's very difficult to determine this information epidemiologically because the levels are so low.

In fact, it is difficult for us even to look at the effect of radon on lung cancer, given the overwhelming effect of cigarettes. So it's going to be a very difficult question to address. I think simply we should remain aware that other cancers may be caused by radon and allow medical research to continue in that area.

Senator MITCHELL. Well, thank you both, very much, your testimony has been very informative and helpful. I think the people of Maine should know that you two are among the nationally recognized knowledgeable persons in the field, and your work is providing information not only to us here in Maine, but throughout the country and we're very grateful to you for that. Thank you.

The next panel will consist of Dr. Keith Hutchinson of Belfast and Miss Eleanor Lacombe of New Gloucester. Why don't you go right ahead, Miss Lacombe. Would you like to start first?

STATEMENT OF ELEANOR LACOMBE

Ms. LACOMBE. My name is Eleanor Lacombe. I'm a research assistant at the Maine Medical Center. But I've been asked to speak here today as a high radon homeowner. I'll try to raise some questions and some needs from the homeowner's perspective. I have worked with Dr. Rand on the Maine Radon Program for a couple of years before I had the water in my own home in New Gloucester tested. So when I received results of the test, I was more familiar than most homeowners of the risk and the options for mitigation. The water level in my well was about 50,000 picocuries per liter.

The air level was only 3.6 or 3.7. This suggests the major problem in my home is water and my house is very drafty, which it is. I elected not to continue to expose myself and my family to whatever

risk it involved with the water radon of 50,000. After talking with Dr. Jerry Lowry at the University of Maine at Orono, who has been working on radon removal methods for several years, I had a charcoal filter intalled at a cost of about $500.

Now, a year later when I checked the level of the water at my kitchen sink, I was not pleased to find that the filter was not working as efficiently as expected. It appears that although charcoal filtration is theoretically very effective in removing radon, there are still some things to be learned about its practical application.

I would suggest there should be some standardization at the State level about the installation of radon removing filters so the most efficient charcoal and tank designs as tested by Dr. Lowry are utilized, and that every effort is made to provide these to homeowner's at the most reasonable prices possible.

Because radon coming from water can be removed by charcoal filtration relatively inexpensively, my radon problem is not as difficult as some. If the radon level in the air is higher than can be explained by water levels, radon is coming from soil gas and the first advice is to seal cracks in basements.

The basement in my 150-year-old farmhouse is a dirt floor, a random rubble and granite foundation, a spring that runs in one corner and out the other. I guess the advice in this situation would be to ventilate the basement, seal it off from the rest of the house, but heat must be maintained because waterlines run through the basement. I'm not sure how this problem could be addressed without prohibitive expense.

We need to have more study on affordable mitigation measures for the type of homes we have in Maine and trained consultants to advise homeowners and contractors. Also, as Dr. Rand suggested, if instrumentation were available that could be taken into homes to pinpoint radon sources, identification of problem areas would be facilitated and unnecessary expense avoided.

We need to have a better understanding of the risk from domestic radon. As Dr. Rand has explained, current risk estimates are based on studies of miners. We hope our work will contribute to this understanding of risk, but at this time it's difficult to give homeowners clear guidance at what levels they should bear the expense of mitigation.

We need to know if there are specific effects to people in showers from being exposed to radon in water, as Dr. Rand has suggested. It is generally considered that the quantity of water that is consumed in a day does not provide a significant exposure, but people who have high water radon are exposed to these high air levels as it escapes during showers and other water use.

Setting a single standard for water is also complicated by variability of homes. Obviously a 10,000 picocuries per liter water value is going to have a much different effect in a house that has .2 air exchanges per hour than one that has two air exchanges per hour.

We also need to know more about air radon in Maine. We realize air radon varies with season, but we need to know how winter measurements compare with year-round measurements and about the influence of frozen ground, snow cover, and wood stoves and how this affects the stack effect. In addition, we need to know where soil and geologic conditions would predict potential radon

problems. If we knew this, homeowners could be advised to take measures that are relatively inexpensive at the time of construction to prevent soil gas from entering the house.

At some levels there is a need for a mechanism for low interest long-term loans for people who can't afford the expense of mitigation.

Finally, homeowners are understandably concerned about what the effects of high radon levels are on the value of their real estate. It is a subject many homeowners will face because in our study, about 25 percent of our homes had water over 20,000 picocuries and/or air over 3 picocuries per liter. But radon, unlike some contaminants, can be removed. It is a matter of proper technology and expense, but the problem can be solved. In no case should the value of the home be affected more than the potential cost of mitigation.

Senator MITCHELL. Thank you, very much, Ms. Lacombe. Mr. Hutchinson.

STATEMENT OF KEITH HUTCHINSON

Mr. HUTCHINSON. I am the owner of a very tightly built house. It's an underground home that I built myself about 5 years ago. The first point I'd like to address is the lack of information available at that time and still unavailable to an awful lot of people who might be planning to build similar kinds of residences. Had I known then what I know now some very simple steps could have saved me a great deal of difficulty.

As things are now, I have to go back and try to trace the problem down and refit the house. I've ended up tearing out the floors that were in the cellar, pouring concrete through a window trying to seal things up and a great deal of difficulty that could have been avoided if information were available.

I am a physician and despite that, the only knowledge I had of radon as recently as 5 years ago was that it was in the water in the State, that it represented a certain risk to people that had that kind of well problem. I was totally unaware of the outgassing and the soil gas. When I made inquiries about it, I didn't find anyone else who knew about it. So clearly it was an area that was little known and the dissemination of this information was certainly a problem that occurred at that point and is still largely unknown.

There was an article about my house in the local paper because of the problem I had, and the kind of questions people asked me indicated that very few people have an awareness of this problem, what it represented as a health risk, and what should be done, in terms of construction, about it.

It leads me to the second major point which is estimating risks. I'm sitting in a house now that has a radon level of between five and eight picocuries per liter, which is still unacceptable. But what does that risk really represent at that level? The data available to the scientific community just doesn't allow them to tell me what I'm really exposing myself and my family to.

So in making a decision about how much to do, what kinds of heroic efforts to launch into as a homeowner, I'm sitting there really not able to make a national judgment. The inclination at this point is for me to do everything possible, except things we

don't know. Clearly there is some kind of risk there and the data is unequivocal and is not estimatable at the present time. I guess the last major points I'd like to make is about the methods of detection as was mentioned.

The present state of the art is not a Track Etch cup. This involves a small piece of film in the bottom of a plastic cup that is left in the house and is exposed to the air for approximately 2 months. You then have to send that to a lab somewhere and depending on the time of the year and how many other people are doing it here in Maine, they send them in a batch in California. You can wait as long as 5 to 6 months to get results and it's never faster than 3 months.

First, you make an original estimate of your problem with that device and when you get back a reading in whatever room you put it and if it's high, you have to somehow decide where it is coming from. If you think about trying to put these cups all over your house at $25 a shot to ferret out the source of this radon, particularly if your problem is soil gas.

My problem continues to come right into the house. I've gone over the place and patched up everything I can see and it's still coming in. I need some way of finding out where that's coming from. Dr. Hess has been very helpful and there is an undergraduate student that is working on a device that will hopefully provide this information to some extent. But right now it's almost impossible to ferret out from where this stuff is entering the house and take what may be very cheap and easy measures. If I knew where it was coming from, it might be easy to fix. But as it stands now we don't have that kind of technology.

Senator MITCHELL. There's no instrumentation or technological device that tells you precisely where it's entering; is that what you're saying?

Mr. HUTCHINSON. I'm sure there are sophisticated devices available, expensive, not portable kinds of things that could probably provide that kind of information. But if you're talking about going out into homes all over the State of Maine and quickly providing people with that kind of information, that doesn't exist at this point and I think that's an important factor. If it is the kind of thing your bill proposes to launch, it would generate that kind of response eventually.

Senator MITCHELL. Do you get your water from a well?

Mr. HUTCHINSON. Actually it comes from a spring so that's one of the reasons I don't have any trouble. The deeper the well apparently the more likely you are to run into radon in the water.

Senator MITCHELL. So your problem is the reverse of Miss Lacombe?

Mr. HUTCHINSON. Much more difficult to deal with unfortunately because of the fact you just don't know where it is coming from so you can't just stick a filter in there.

Senator MITCHELL. Well, thank you both very much. That's very helpful. I appreciate it. The next panel consists of four persons. Mr. Lee Shibles of the Southern Maine Vocational Technical Institute, Marshall Burk, director of environmental health with the Maine Lung Association, Charles Hillier, research director of the Maine

State Employees Association, and Mr. Jeff Thaler, executive director of the Maine Audubon Society.

Well, I recognize Mr. Shibles, Burk, and Hillier, but you don't look anything like Jeff Thaler. So we'll begin and why don't we take you in the order listed, unless you prefer otherwise. Mr. Shibles was first.

STATEMENT OF LEE SHIBLES, SOUTHERN MAINE VOCATIONAL AND TECHNICAL INSTITUTE

Mr. SHIBLES. Thank you, Senator Mitchell. My name is Lee Shibles. I am an instructor of building construction at Maine Vocational Technical Institute. As you're probably aware, this is a post-secondary institution with approximately 1,200 full-time day students and 6,000 adult education students.

We are very concerned with radon as it might affect our students and faculty.

Senator MITCHELL. Not only am I aware of it, but I live about 500 yards from there and I enjoy visiting the institution regularly.

Mr. SHIBLES. Back in the summer of 1983, I sent to Terradex Corp. in California for a track cup. I was curious when some of the materials we were using in our building construction program contained radon. When we came back to school in September, we placed the cup in the commercial construction lab on top of the aggregate bin.

After 5 days we sent it to Terradex for a reading. We got a reading of 8.3 picocuries per liter. The report stated that 4 picocuries per liter was considered high, four to six EPA's limits for inactive uranium processing sites.

This report was dated December 14, 1983. After the Christmas break, I met with director Wayne Ross of SMVTI and we went over the problem. At that point we didn't know exactly where the radon was coming from, whether it was coming from the aggregate, whether it was coming from the concrete block den that the aggregate was placed in, the concrete wall, which was behind the bin, or from an open ledge within the shop, or even the air within the shop itself.

In February we contacted Wallace Hinckley of the division of health engineering here in Augusta. Due to commitments by the State, there was some lapse of time before we could obtain any more cups. We did obtain two cups from the department of health and engineering. We placed one of the cups in the same spot as the original. The second was placed in my office, which is on the same floor, which happens to be in the basement area of this particular building.

The readings came back as follows: 8.72 picocuries per liter. This was in the same place as the previous 8.36. In my office it was 9 picocuries per liter. I attended a conference in the fall of 1984 and Bill Turner from the Harvard School of Public Health gave me Dr. Peter Rand's name. I contacted Dr. Rand who came over immediately. He took some samples of the aggregate off some of the ledge. I believe he even took some of the dirt floor. Part of the shop does not have a concrete floor in it.

With the assistance of Dr. Rand and some equipment from the University of Maine, Wally Hinckley brought this down to us and we tested the entire shop from November until it was either the last of February or the first of March. We found that radon was somewhat confined to the ledge area and under the floor in the concrete lab.

They sent us two more new types of Track cups. We placed one actually under the concrete floor section of the shop and we placed one on the ledge. We sealed the ledge so that we were only getting readings from the ledge itself. We placed the cup under plastic.

The findings came back under the floor readings of 1,212 picocuries per liter. And on the ledge 58.58 picocuries per liter. This pretty much verified that the hot spots in our particular building were under the floor and on the ledge.

We have since contacted the various States agencies and it looks like very shortly that we will be putting in some air-to-air heat exchangers to try to ventilate the problem out of existence, if possible. Presently, we're ventilating. It seems to have worked. It's very primitive. We open a 12-by-12 overhead door once a day. And it's the best that we can do at this point.

That completes my formal testimony. I would like to extend to you, and the Federal Government, the Environmental Protection Agency, a possibility of using our site. We certainly have the radon. Not only that, but 200 feet away from this site we have constructed a 24-by-40-foot superinsulated modular house which we are using for test purposes. This would be an excellent site for you to consider.

In this particular building we have everything that you've asked for. We do not have a concrete floor in it. All we would have to do is drill a well and I'm sure we could find radon in the water, too. You might consider using SMVTI as a site. You have experts in the area. Dr. Rand is just across the river from us. Possibly he could head up the testing.

Senator MITCHELL. That's a very kind invitation, Mr. Shibles. You have got me a little bit worried since my house is a few hundred yards of where you've been describing. Fortunately, my home is very drafty, but I better doublecheck now and I think it's very kind of you to suggest that. We will pass that along to the EPA. Mr. Burk?

STATEMENT OF MARSHALL BURK, DIRECTOR OF ENVIRONMENTAL HEALTH, MAINE LUNG ASSOCIATION

Mr. BURK. Senator Mitchell, my name is Marshall Burk. I am director of environmental health for the Maine Lung Association, Augusta, ME. The Maine Lung Association is the State's oldest voluntary health association founded in 1911. The association is supported by more than 60,000 Maine citizens annually. Our mission is the prevention and control of lung disease.

Thank you for the invitation to testify on the subject of indoor air pollution and exposure to radon gas.

The association recognizes that the average American spends at least 90 percent of his time indoors, 60 percent at home. We are also concerned that the people who are especially susceptible to

lung health problems are the very ones who spend most of the time at home, babies, pregnant women, the elderly, and those who have heart and lung diseases.

The lung association has for some years recognized the possible harm of radon gas in Maine homes. The association's board of directors in December 1981, voted to help fund the preliminary studies on health effects of radon and its possible relationship to Maine's high rate of lung diseases. We continue to endorse research in this area.

Radon, however, is only one of the recognized problems of indoor air quality. The major problems associated with chemical and biological indoor air contaminants which have become the increased concern in recent years are biological aerosols, such as bacteria, virusus, pollens, molds, and animal bander, formaldehyde; asbestos fibers; carbon monoxide, sulfur dioxide, nitrogen dioxide, and other products of combustion, toxicants in commonly used household products, such as pesticides, and cleaning agents and tobacco smoke.

Just 3 months ago on May 3, 1985, in observance of National Clean Air Week the association conducted here in Augusta a day-long workshop for homeowners of the topic air pollution in the home. This conference was attended by about 100 citizens concerned with the quality of their home environments. Most had problems to solve, and were seeking an opportunity to ask questions of the various authorities who spoke. All of the major indoor air pollutants were discussed.

One newspaper reporter made a special note in his report of the presentatioin by one of Maine's leading pulmonary physicians who discussed the effects of tobacco smoke. This physician was quoted as stating in the home parental smoking is a form of child abuse and smoking is the most dangerous of the indoor pollutants and is the easiest to control and is very pleased to note Commissioner Petit's reference to that fact today and what the department of human services is going to do as far as getting a policy going.

The Maine Lung Association receives about one or two inquiries a week from homeowners across the State concerned with the quality of the air inside their homes.

We believe that to protect public health a prime objective for Federal and State public health agencies should be to limit the total human exposure to air pollutants, rather than only the fraction which occurs in the outdoor air.

Furthermore, indoor air quality should be maintained at levels known and proven to protect even the most sensitive of the public from short-term and long-term adverse health effects and discomfort. The American Lung Association has adopted the position and I quote, accurate date on sources of indoor pollutants are needed to implement control strategies to reduce indoor pollutants.

Research on the possible health effects of indoor and outdoor air pollution should be increased and integrated to permit the development of appropriate control strategies. Congress should designate the U.S. Environmental Protection Agency as the agency with primary jurisdiction on research of health effects of indoor pollution for restrictions for establishing and enforcing control programs.

And may I add that we strongly believe a State agency here in Maine should be designated to handle indoor air pollution problems at the local level, as well.

I conclude my comments today with a request that you include into the hearing record the excellent publication, "Air Pollution In Your Home," prepared by the American Lung Association. Thank you for the opportunity to testify. We would be pleased to answer any questions.

Senator MITCHELL. Thank you, Mr. Burk, the document will be included in the hearing record. (See p. 52.) Mr. Hillier?

STATEMENT OF CHARLES HILLIER, RESEARCH DIRECTOR, MAINE STATE EMPLOYEES ASSOCIATION

Mr. HILLIER. Thank you, Senator. I'm Chuck Hillier from the Maine State Employees Association. We at the Maine State Employees Association have had significant experience with indoor pollution. As Commissioner Petit mentioned, in one of his department buildings in Aroostock County there were gasoline and petroleum products seeping in the basement.

There are other situations where basically petroleum products were introduced into the worksite from outside sources, but there is one situation that is perhaps the most serious and we've been unable to find the cause of the problem. The problem is located in the State's department of transportation building.

The Department of Transportation building is a modern office building constructed in the mid-seventies, tightly insulated and atmospherically controlled by a ventilation system. Soon after completion, employees, some 500 of them, moved into the building to start work there. We started getting complaints of various types of symptoms from something in the building. These complaints range from difficulty breathing, drowsiness, eye irritation, skin rashes, things of that nature.

The State epidemiologist, Dr. Steven Siniski, was enlisted to conduct a study of what the problem might be or how widespread the problem was and I'll quote from his report:

> Approximately 75 percent of employees who work in the new DOT building are affected by a group of symptoms whose cause is not known. The symptoms that remain to date are excessive thirst, dryness of mucosal membranes, blurred vision, and drowsiness. These symptoms occur with a significantly higher frequency in State employees in the DOT building than State employees in other buildings. Symptoms usually begin in the morning, last all day, rarely occurred away from work, and usually occur year round.

After Dr. Siniski's report came out, the State and MSEA again enlisted the support of experts from OSHA and from the National Institute of Occupation Safety and Health. After their extensive studies they were still unable to find what the problem was.

A consulting engineer was hired to look at the building to see what problem might be in the structure of the building, found that the ventilating system was not working up to specifications. That was corrected and some of the symptoms were mitigated as a result of that but not gone away. Today, there are still people who are under doctor's orders not to enter the building at all. Two people were diagnosed to have obstructive lung illness as a result of working in the building. Others have had serious sinus conditions. And

as I say, even today skin rashes, sore eyes, drowsiness is still occurring in the building amongst employees there.

Initially we thought that smoking in the building might be the problem. But that turned out not to be the case as it became apparent that the symptoms showed up most frequently and most virtually on Monday morning after the building had been empty over the weekend. And so we're here to speak in support of your bill so that we can find a solution to that problem and any others that I'm sure exist in modern, tightly built office buildings around the State and the country.

Senator MITCHELL. Thank you, very much, Chuck. Now, substituting for Jeff Thaler is Jean Scudder of the Maine Audubon Society. Welcome.

Ms. SCUDDER. Thank you. I'm glad you observed I'm not Jeff Thaler.

Senator MITCHELL. After 5 years of politics you get to be a little observant. It's taken a lot of experience to make these observations.

STATEMENT OF JEAN SCUDDER, MAINE AUDUBON SOCIETY

Ms. SCUDDER. My name is Jean Scudder and I work at Maine Audubon's advocacy department. Traditionally, environmentalists and researchers have concentrated on outdoor air pollution and it's only recently that we've begun to realize that these pollutants may be at times more serious indoors. That's why last December Maine Audubon researched, drafted, and introduced legislation to study the potential health effects of residential wood heating. That's why today we also vigorously support S. 1198, the Indoor Quality Research Act of 1985.

Other witnesses have talked fairly extensively about radon. We'd like to concur that we feel that's a very serious problem for Maine and for the country. Over 90 percent of America's rural population depends on ground water, almost entirely for its water supply and the presence of radon in our drinking water, washwater, and in the air we breathe, therefore, represents a danger to which must be responsible and thoroughly investigated.

Today, I would like to call the committee's attention to other and less publicized contaminants to indoor air, which we feel pose a clear and present danger to the public health.

First, I'd like to discuss gasoline fumes, which we heard a few mentions of, residential wood stove emissions, and home chemicals.

Gasoline fumes are something many of us are familiar with, almost all of us have gas cans in our garages, many of us do handle it carefully. I think few of us realize, however, that gasoline is a suspected carcinogen and is toxic. In fact, the American Petroleum Institute is now recommending that warnings go on all gas pumps warning users of its potential danger.

Far more along is the now more common incidence of gas vapors entering the home through basements very similar to the radon problem. There have been well over 200 petroleum spills in the State of Maine into ground water from underground storage tanks. And when gasoline enters the ground water supply, it is all but impossible to remove. Many people draw gas-contaminated water into

their homes for a period of years before they realize what the problem is and they report it. And as we've heard discussed before running hot water which is contaminated in gasoline in dishwashing to be dermally absorbed. And and April 1985, issue of Inside EPA states that gas vapors pose 4 to 10 times the risk that is posed by benzene, which is a known and well accepted carcinogen.

When gasoline-contaminated water is run in a home, that's the most significant instance that we've seen, adverse health effects have been reported by homeowners throughout Maine to families and to animals. And at this point this is a really new area where only a very, very small amount of data is available. However, there is a disturbingly high death rate among animals. Renal and liver tumors have been found in experimental animals exposed to benzene.

Gasoline fumes are definitely a topic requiring more research by EPA. And given the States estimate of 11 millions gallons of petroleum products leaking in Maine's soil and water each year, we feel that it is an area needing more attention.

Second, I'd like to discuss wood stove emissions. We have at Audubon advocated the use of wood and feel that it's very important to look at the potential impact of using wood as a secondary heating source. There's been a dramatic increase in residential use of wood for home space heating. Since 1982, residential wood use has more than tripled in Maine and nationally about 15 million wood buring stoves and fireplace inserts are used with over 2.2 million units sold in 1983 alone.

As with other air pollutants, the primary focus of the EPA and researchers has been on the impact of wood smoke on outdoor air quality. And again, the July 1985 EPA proposal to issue regulations for wood stoves is concerned with outdoor conditions and ignores the possibility of indoor impact of these millions of existing stoves.

Wood-smoke emissions from incomplete combustion in residential stoves contain carbon monoxide, the cancer-causing benzoapyrene, and polycyclic organic compound, and other chemicals with irritant and long-term effects. In Maine alone, the DEP's recent inventory found annual emissions of over 7 tons of benzoapyrene.

Wood-smoke emissions potentially threaten up to 270,000 of Maine's most susceptible citizens. These are the elderly, the young, the people with chronic pulmonary diseases. Particulate matter emitted from residential wood stoves is in the size range which can be absorbed deep within the lungs.

And one of the only studies which has been done to date is called the Michigan study reported in the March 1985 issue to Pediatrics which we've included our testimony reports that the occurrence or respiratory problems is much greater among children from homes heated by wood than among children from homes with other heat sources. They tested 62 children in this study ages 1 to 7 and the greatest impact was in the category of severe symptoms of acute respiratory illness among these children.

The Michigan findings suggest that preschoolchidren are particularly vulnerable to indoor contamination from wood smoke and may develop lifelong respiratory illnesses. A limited EPA survey of five Oregon homes in 1981 found that improper stove maintenance

or operation can cause much longer indoor levels of partciculates and hydrocarbons than optimum.

In fact, the levels seen in one house of the carcinogen benzoapyrene approximated 10 to 38 cigarettes per day for the inhabitants.

Additional research is necessary concerning the effects of indoor levels of the wood-smoke emissions of human health, as well as controlled technology or mitigation measures. Maine Aududon strongly urges the inclusion of residential wood-burning emissions and the proposed EPA Indoor Quality Air Research Program.

The lastest thing I'd like to speak about is household chemicals is something many people think about, very little is known about, and we're all a little afraid of hearing about. Commonly used chemicals, such as laundry soil and stain removers, dry cleaning fluid, and drain, toilet, and cesspool cleaners, are composed of petroleum distillates and some of the most toxic organics that we are aware of. These chemicals may reenter the home of office place in vapor form or through one's contaminated ground water supply.

Thus people indoors may be inhaling toxics, such as perchloroethylene, tetrachloroethylene, and its relatives. They produce a wide range of serious chronic effects in humans or test animals, including cancer, mutations, neuromuscular and neurotic effects.

The list of common, yet seriously harmful chemicals, includes paints and thinners, chlorine and disinfectants, glues, fabrics and construction materials—of course, formaldehyde is a familiar subject to us now, not only must we research the toxicity of each of those substances in air quality individually, but I would like to stress that we must also assess their cummulative impacts.

In conclusion, Maine Audubon Society believes that environmental protection must take place not only in the mountains or in the rivers, but where we live, which is to a large extent as many people have said today indoors. Senator Mitchell's proposal for the research program with respect to indoor air quality is a significant first step. The program's findings will then serve as a foundation for the protection of our health and that for our children. Thank you, very much.

Senator MITCHELL. Thank you, Miss Scudder. If you're aware, have the manufacturers of wood stoves been responsive to the concerns raised about the effect of their use on air quality?

Ms. SCUDDER. We are not aware of any incentives on the manufacturers part, other than working on the catalytic converters which will not solve the problem.

Senator MITCHELL. So other than that, there's been no change in the manufacturer or design of these stoves?

Ms. SCUDDER. Not that we are aware of, no.

Senator MITCHELL. Well, thank you all very much for your testimony. I appreciate it. It will be very helpful. That concludes the panel of listed witnesses. If there's any member of the public, anyone who did not testify who would like to say something, I'd be very happy to hear from them before we close the hearing. Is there anyone that would like to say anthing on this subject?

If not, then on behalf of the committee, I thank all of the witnesses and others who attended. This is a serious problem. We are in the beginning stages of an effort to deal with it. Testimony and statements we received here today will be very helpful to the com-

mittee in considering this and other legislation. I might add, as a matter of interest, at least two other bills have been introduced in the Senate since I introduced this legislation dealing in various ways with the problems of radon in homes and I hope that the committee will be acting on this when we return after Labor Day.

That concludes the hearing. Again, I thank you all very much for coming.

[Whereupon, the hearing was adjourned to reconvene at the call of the Chair.]

[Statements submitted for the record and the bill, S. 1198 follow:]

52-630 O—85——3

TESTIMONY OF

HUMAN SERVICES COMMISSIONER MICHAEL R. PETIT

BEFORE

ENVIRONMENTAL AIR PUBLIC WORKS COMMITTEE

ON

INDOOR QUALITY RESEARCH ACT OF 1985

AUGUST 5, 1985

THE DECLINE OF INDOOR AIR QUALITY IS A PROBLEM WHICH IS BEING OVERLOOKED OR ONLY BEING PARTIALLY ADDRESSED SINCE THERE ARE ONLY A FEW STATE AND NO FEDERAL PROGRAMS SYSTEMATICALLY WORKING ON THIS PROBLEM. THE DECLINE OF INDOOR AIR QUALITY STEMS FROM THE INTRODUCTION OVER THE PAST 30 YEARS OF MECHANICAL VENTILATION SYSTEMS AND SYNTHETIC BUILDING PRODUCTS. THE PROBLEM HAS BEEN COMPOUNDED BECAUSE OF ENERGY CONSERVATION MEASURES TO TIGHTEN UP HOMES. SOME OF THE TYPICAL POLLUTANTS OF CONCERN HERE IN MAINE ARE RADON, TOBACCO SMOKE, COMBUSTION PRODUCTS, ASBESTOS, FORMALDEHYDE, ORGANIC COMPOUNDS, PESTICIDES, PARTICULATES, ODORS AND AIR IONS. THESE CONCERNS ARE DESCRIBED IN GREATER DETAIL IN APPENDIX I. I MIGHT POINT OUT, HOWEVER, THAT THIS LIST ONLY SCRATCHES THE SURFACE.

SINCE MOST PEOPLE SPENT 90% OF THEIR TIME INDOORS, IT IS ESSENTIAL THAT WE UNDERSTAND AND MINIMIZE THE HEALTH RISKS DIRECTLY ASSOCIATED WITH INDOOR AIR CONTAMINANTS. MOST VULNERABLE TO THESE POLLUTANTS ARE THE ELDERLY, INFANTS, THE CHRONICALLY ILL, AND EXPECTANT MOTHERS.

IN ADDITION TO THE THREAT POSED TO HEALTH, THERE IS ALSO A FINANCIAL COST WITH ESTIMATES THAT INDOOR AIR POLLUTION MAY BE CONTRIBUTING ANYWHERE FROM $15 BILLION TO $100 BILLION ANNUALLY TO OUR NATIONAL HEALTH CARE COSTS.

STATE EFFORT TO DATE:

OVER THE PAST FEW YEARS THE DEPARTMENT OF HUMAN SERVICES HAS BEEN VERY MUCH INVOLVED IN THE PROBLEM OF RADON. A PORTION OF THE STATE'S PREVENTION BLOCK GRANT HAS BEEN INVESTIGATING THE POSSIBLE LINK BETWEEN RADON AND CANCER. APPENDIX II DESCRIBES THE PROBLEM AS WE UNDERSTAND IT AND SUMMARIZES MANY OF OUR ACTIVITIES TO DATE. I EXPECT THAT OTHER SPEAKERS WILL ADDRESS CURRENT RESEARCH ACTIVITIES AND NEEDS.

WITHIN THE PAST COUPLE OF MONTHS, BECAUSE OF INCREASED REQUESTS FOR ASSISTANCE IN THIS ENTIRE AREA, THE DEPARTMENT HAS FOUND IT NECESSARY TO REASSIGN A CHEMICAL ENGINEER AND A FIELD TECHNICIAN TO START DEVELOPING A STATE RESPONSE TO OTHER AIR POLLUTION CONCERNS.

NEEDS FROM FEDERAL LEVELS:

FEDERAL ACTIVITIES ON INDOOR AIR ENVIRONMENT HAVE BEEN LIMITED, SPORADIC AND UNDERFUNDED. THIS IS VERY UNFORTUNATE SINCE THE PROBLEM IS CLEARLY A NATIONAL ONE AND IS OF SUCH SCOPE THAT IT REQUIRES FEDERAL RESOURCES TO ADDRESS SUCH NEEDS AS:

1. APPROPRIATE AIR STANDARDS:

MOST OF THE AIR STANDARDS ARE BASED ON HEALTHY ADULTS EXPOSED FOR 40 HOURS A WEEK OVER A WORKING LIFETIME OR IN THE CASE OF OUTDOOR AIR POLLUTION THE PEOPLE SPENDING 15 OR 20% OF THEIR TIME OUTDOORS. THESE STANDARDS ARE INADEQUATE TO ADDRESS THE RESIDENTIAL OR SETTING OCCUPIED BY INFANTS, THE ELDERLY, AND PEOPLE THAT ARE MUCH MORE SUSCEPTIBLE.

2. SIMPLE TESTING METHODS:

DEVELOPING, EVALUATING AND STANDARDIZING SIMPLE METHODS FOR TESTING POLLUTANTS IN AIR IS A MUCH-NEEDED AREA FOR RESEARCH AND SCIENTIFIC INTERVENTION. MUCH OF THE PRESENT METHODOLOGY INVOLVES EXPENSIVE EQUIPMENT OR LAB PROCEDURES AND IS EXTREMELY LABOR INTENSIVE. RESEARCH IS NEEDED TO DEVELOP PASSIVE TYPE TESTING DEVICES WHICH CAN BE MAILED TO HOMEOWNERS TO ALLOW THEM TO PERFORM THEIR OWN SAMPLING AND IN SOME CASES THEIR OWN ANALYSIS.

3. POLLUTANT PROJECTION MODELS:

THE STATES NEED FEDERAL ASSISTANCE IN DEVELOPING MODELS TO ASSIST IN PROJECTING WHAT POLLUTANTS MIGHT BE PRESENT. SINCE INDOOR POLLUTANTS CAN RANGE FROM PARTICULATES TO RADIATION TO SEVERAL DOZEN ORGANIC COMPOUNDS, IT IS ESSENTIAL TO HAVE SOME IDEA WHAT POLLUTANTS TO EXPECT, BEFORE CONDUCTING A FIELD INVESTIGATION OR PROVIDING THE HOMEOWNER WITH A TEST KIT.

4. PUBLIC INFORMATION

DEVELOPING EASILY UNDERSTOOD HEALTH RISK INFORMATION FOR THE GENERAL PUBLIC, DESCRIBING RISK AND TYPICAL BACKGROUND INDOOR AIR LEVELS AND RECOMMENDING PROVEN CORRECTIVE MEASURES ARE ALSO ESSENTIAL. AGAIN, THE STATES ARE SIMPLY NOT EQUIPPED TO ADDRESS THESE PROBLEMS INDIVIDUALLY.

IN SUMMARY, THE DEPARTMENT OF HUMAN SERVICES COMPLIMENTS YOUR LEADERSHIP FOR INTRODUCING S1189. WE STRONGLY SUPPORT ITS INTENT AND AGREE THAT MORE RESEARCH IS NEEDED IF WE ARE TO ADEQUATELY ADMINISTER AN INDOOR AIR POLLUTION PROGRAM. A NATIONAL INITIATIVE IS ESSENTIAL BECAUSE THE STATES SIMPLY DO NOT HAVE THE CAPACITY TO INDEPENDENTLY DO THE RESEARCH AND DEVELOPMENT NEEDED IN THIS AREA.

APPENDIX I

Sources of indoor air pollution are varied and many. Pollutants can come from outside the home, from objects and activities inside the home or even from the structure itself. Many factors, such as the surrounding soil, the water supply, the prevailing winds, presence of other structures nearby and weather conditions can affect indoor air quality. The problem is further complicated by the fact that the pollutants may be released continuously or periodically depending upon the pollutant and its source.

Some of the typical pollutants of concern here in Maine are:

Tobacco Smoke. Smoke was probably the first indoor pollutant. Smoke from the tobacco poses a major health hazard. Exposure of nonsmokers to side-streamed smoke is involuntarily subjecting large populations to a significant health hazard. It appears that prolonged exposures of side-stream tobacco smoke significantly increases the risk of disease in otherwise healthy individuals;

Radon. Radon is a controversial pollutant. Scientific opinion is split as to whether it may or may not cause up to 20% of the lung cancer in the United States. Radium 222 is a radioactive gas which results from the decay of radium 226. The soil is believed to be a major source of radon but building materials may also contain large amounts of radioactive substances. An inert gas, radon may diffuse directly into buildings and other closed spaces and here in the Northeast ground water may also be a major source of increased radon levels. Inside a building, radon produces alpha particles, which have a powerful biological impact. Although studies have been made, more and better data on radon in buildings is needed. The Environmental Protection Agency estimates that radon may be the second leading cause of lung cancer. If this is true, then the risks involved are great and there is a need to minimize exposures to this pollutant;

Combustion Products. Combustion indoors produces a variety of pollutants very common in most U. S. households. Sources of these combustion products in the homes are usually associated with heating equipment such as gas, oil, kerosene, and wood. Carbon monoxide is the most widely recognized combustion product pollutant with nitrous oxide, sulfur dioxide, particulates, carbon dioxide and formaldehyde as the other major pollutants. Due to the high costs of energy, more and more people in the Northeast are relying on wood for space heating and with the advent of the air tight stove, a variety of exotic organic compounds are being produced. Little is known about the compounds being produced or their potential health effects. Unvented kerosene heaters (such as Kero-sun) are fairly new items on the market and have also been found to contribute to indoor pollution;

Asbestos. Asbestos is one of the most pervasive indoor air pollutants. Asbestos has been used for thousands of years but in significant amounts only this century. It has been used in fireproofing and in thermal, electrical and acoustical insulation as well as for decorative purposes. There are presently over 3,000 consumer products that contain asbestos. Schools seem to be involved with particular frequency. All indications are that asbestos is a silent health hazard in our midst whose ultimate human damage we have yet to barely understand;

Formaldehyde. Formaldehyde is one of the most publicized of all indoor air pollutants and is also currently subject to both research and interim regulatory actions. Problems with this pollutant have been most closely associated with two major consumer products, mobile homes and urea formaldehyde home insulation. In fact, it was urea formaldehyde foam in mobile homes that basically brought to light much of the concerns about indoor air contaminants. Formaldehyde is also produced by combustion, tobacco smoking as well as gas stoves, wood stoves, kerosene space heaters, etc. Formaldehyde is not only an irritant but it may cause chronic health problems. The most perplexing question is as to what level of this pollutant is safe since a small portion of the population can become sensitized to formaldehyde, and thereby be affected by much lower levels than would make the average person ill;

Organic Compounds. Evidence is accumulating that indicates that new buildings have more and higher concentrations of organic pollution than older buildings. Sources of some of these organic pollutants are materials and products designed for indoor use, construction materials, furniture, draperies, cleaning products, room deodorizers, etc. or even the chemicals associated with cooking, fire places, hobby materials, painting, stripping, soldering, etc. emit low concentrations of a variety of organic compounds. Little is known about the potential health affect of these compounds at these exposure levels;

Pesticides. It is estimated that 91% of the households use pesticides within the home, on the lawn or in their gardens. Pesticides have become indoor pollutants from several sources. Some include the application of pesticides by professionals. Others include such things as mothballs, pesticide strips, flea collars, etc. In general, pesticides are widely used in indoor environments often despite their toxicity. Often care is not exercised in their use. The philosophy "more is better" is not uncommon when applying pesticides;

Particulates. Particulates come in all sizes, shapes and may be solid or liquid. Some of the main classifications of particulates include dust droplets, allergens such as pollen, bacteria, viruses, fungi, fibrous particles, particulates generated from tobacco smoke, combustion products etc. Tobacco smoke is believed to be by far the most significant contributor of indoor air particulate concentration;

Odors. Control of odor has probably been ranked as the number one reason for maintaining public ventilation standards. Odor has been shown to cause sensation of nausea, dizziness, and headaches and in general can cause discomfort for many people;

Air ions. Air ions are molecules that are normally found in ambient air. Considerable research is going on attempting to address whether air ions in fact do have a significant affect on human health. There is increasing evidence that suggests that air ions need additional study;

Resource Highlights

RADON IN WATER AND AIR

Health Risks and Control Measures

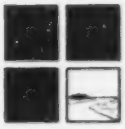
AN INFORMATIONAL DIGEST PREPARED AND DISTRIBUTED BY

THE LAND AND WATER RESOURCES CENTER
UNIVERSITY OF MAINE AT ORONO

and

THE DIVISION OF HEALTH ENGINEERING
MAINE DEPARTMENT OF HUMAN SERVICES

February, 1983



Page

THE CHEMICAL ELEMENT RADON IS ONE STAGE OF A NATURAL RADIOACTIVE DECAY CHAIN. 2

LEVELS OF BACKGROUND RADIATION DUE TO THE PRESENCE OF RADON ARE RELATIVELY HIGH IN SOME SECTIONS OF MAINE AND NEW ENGLAND. 3

THE RADIOACTIVE DECAY OF RADON PRODUCES FAST-MOVING SUBATOMIC PARTICLES THAT CAN DAMAGE LIVING CELLS. 4

RADON IS LIKELY TO AFFECT PEOPLE MORE THROUGH THE AIR THEY BREATHE THAN THE WATER THEY DRINK. THE BEST INDICATION OF HEALTH RISKS OF AIRBORNE RADON ARE LUNG-CANCER MORTALITY RATES OF URANIUM MINERS IN POORLY-VENTILATED MINES. 5

HEALTH RISKS CAN BE ESTIMATED FOR VARIOUS LEVELS OF AIRBORNE AND WATERBORNE RADON, AND THEY ARE HIGH ENOUGH IN SOME MAINE HOMES TO BE CAUSE FOR CONCERN. 6

THE HEALTH RISKS OF RADON CAN BE PUT IN PERSPECTIVE BY LOOKING AT OTHER CAUSES OF DEATH, OTHER SOURCES OF LOW-LEVEL RADIATION, AND VARIOUS STANDARDS THAT HAVE BEEN USED FOR AIRBORNE RADON LEVELS. 7

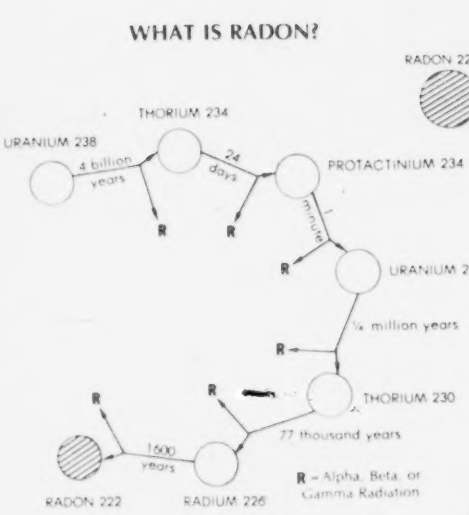
HIGH RADON LEVELS IN A HOUSE MAY BE CAUSED BY RADON IN WELL WATER, SOIL GAS SEEPING INTO THE HOME, OR, IN EXCEPTIONAL CASES, CONSTRUCTION MATERIALS. 8

WATER-USING HABITS, TYPE OF CONSTRUCTION OF THE HOME, AND VENTILATION RATES ARE KEY FACTORS AFFECTING LEVELS OF AIRBORNE RADON. 9

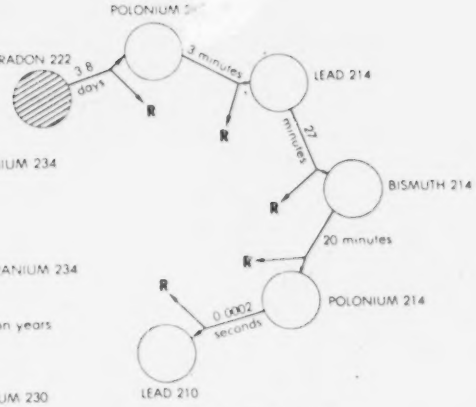
METHODS ARE DESCRIBED

- FOR REDUCING RADON LEVELS IN HOMES 10
- FOR GETTING WELL WATER AND AIR SAMPLES TESTED 12

WHAT IS RADON?

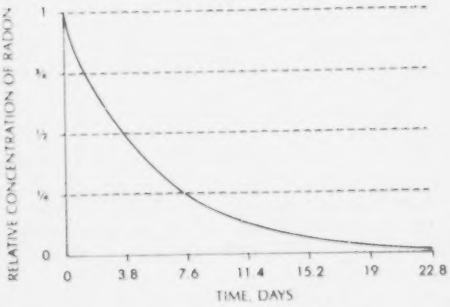


FORMATION OF RADON



RADON'S PROGENY

Radon is a naturally occurring radioactive gas found in low concentrations almost everywhere on earth. It is colorless, odorless, and chemically inert, like helium, neon, and the other so-called "noble" gases. It is fairly soluble in water.



DECAY CURVE FOR RADON

Radon is the immediate product of the radioactive decay of the element radium. However, radon is midway in a chain of radioactive transformations originating with uranium, which has such a long half-life as to have been present at the formation of the earth.

The chain of radioactive transformations does not end with radon. Indeed, it is the radioactive decay that can affect living organisms. Every atom of radon undergoes a series of transformations, emitting alpha, beta, and gamma radiation. The radioactive elements that result from the decay of radon are called "radon progeny" or, sometimes, "radon daughters". Because of these processes, when radon is present in air or water, radon progeny are also present.

For purposes of clarity, the diagrams above have been simplified with respect to the by-products of the radioactive chain. The time information on the diagrams represents "half-lives". That is, these numbers indicate how long it takes for half the atoms of each element to decay.

The half-life for radon is 3.8 days. As the graph at left shows, every 3.8 days, the concentration of radon falls by a factor of one-half.

In a normal environmental situation, the decay of radon is accompanied by the continual replenishment of fresh radon. Thus the concentration of radon in water and air in the home does not follow the pattern shown in the graph.

Concentrations of radon progeny, which have half-lives ranging from fractions of a second to tens of minutes, generally follow the concentrations of the much longer-lived radon. Such concentrations may vary from the radon concentrations, however, depending on specific removal processes.

WHERE DO RADON LEVELS TEND TO BE HIGH?

	Number of wells Tested	Average Radioactivity of Well Water (pCi/L)*
CHLORITE ZONE (metasediments)	56	1,100
GRANITE	136	22,000
SILLIMANITE ZONE (Metasediments)	35	13,600

*pCi/L, the abbreviation for picoCuries per Liter, is used as the radiation unit of measure throughout this report. The prefix "pico" means a multiplication factor of .000001. A Curie is a commonly-used measurement of radioactivity.

ALL GROUNDWATER CONTAINS SOME RADON AND THEREFORE SOME DEGREE OF RADIOACTIVITY. RADON LEVELS VARY CONSIDERABLY FROM ONE AREA TO THE NEXT BECAUSE OF DIFFERENCES IN BEDROCK GEOLOGY. IN MAINE, SOME AREAS HAVE RELATIVELY HIGH RADON LEVELS.

The fact that radon is naturally present in well water (as well as the soil) has been known since the first decade of this century. It has only been in the last 20 years or so that an awareness has developed that radiation from natural sources may be high enough, in some cases, to represent health risks. In the 1960s and early 1970s it was discovered that the radioactivity of water from many wells in Maine were above some suggested drinking water standards. Then in the late 1970s, researchers at the University of Maine at Orono found:

- Radon is present in Maine's well water in varying amounts. Radioactivity of the well water from 2,000 wells tested averaged approximately 10,000 pCi/L. (These wells did not represent a random sampling.)
- In general, radon concentrations are highest in granite bedrock.
- Public water supplies have relatively low radon levels.

The map and figures above summarize the relationship between radioactivity of well water and bedrock geology. As can be seen, radon levels are somewhat high in "sillimanite" zones. (Sillimanite is a grade of metamorphized sedimentary rock.) The number of tested wells with known geological conditions represents only a fraction of the 2,000 wells that have had water tested for radon over the last decade.

The bedrock geology of Maine is quite complex, and the map above represents a simplification of actual conditions. Generally, the granite and sillimanite bedrocks in the southern part of the state have been buried deep, in the geologic past, and been subject to considerable heat and pressure.

The relationship between granite bedrock and high radon levels occurs in other sections of the United States and throughout the world. Indeed, it can be anticipated that radon levels like those found in Maine may exist in other sections of Northern New England and along the eastern side of the Appalachian Mountains.

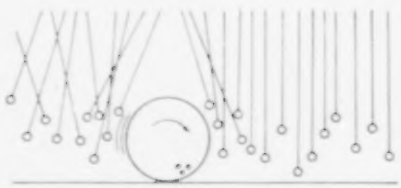
As soon as groundwater is brought to the surface and exposed to the air, it begins to lose radon to the air. This is why radon levels in lakes and other surface waters are low. This is also why water from public water supplies—stored in elevated tanks or reservoirs before it is distributed—has low radon levels even where the water was originally obtained from wells.

HEALTH EFFECTS OF RADON

What happens when radon and radon progeny are inhaled or ingested? Because radon is chemically inert, radon that is inhaled is also exhaled. The radon progeny, however, are chemically active, being metals, such as lead, bismuth, and polonium. These elements will stick to anything with which they come into contact, such as particulates in the air and on furniture and room surfaces. When inhaled, 30% of the radon progeny, both attached to particulates and free, come into contact with air passageways in the lungs and adhere to the surfaces. Radiation from such radon progeny can strike and break molecules in living cells.

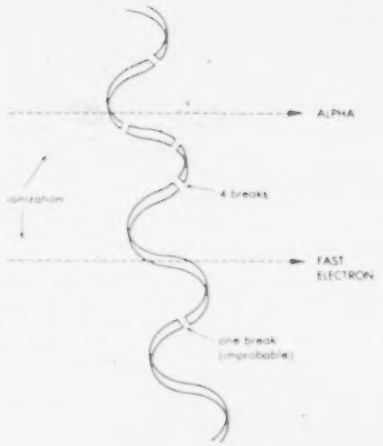
Radon progeny ingested with water cannot pass through the walls of the gut into the blood. However, radon itself can diffuse through the wall of the gut (or is burped out). The progeny of such radon can affect the stomach and other organs (but normally in such small amounts as to be insignificant compared with radon entering air passageways).

The health risks of radon and radon progeny are mainly due to the emission of alpha particles by several of the radon progeny. (An alpha particle is really a helium atom moving at high speed.) Alpha particles lose speed as they pass through matter and knock electrons off molecules of such matter. This process, called "ionization", is similar to a situation where a bowling ball would be slowed down by hitting marbles suspended on strings. Because the marbles have so much less mass than the bowling ball, the ball will only be stopped after hitting a great many marbles.



BOWLING BALL (ALPHA PARTICLE)
HITTING MARBLES (ELECTRONS)

Alpha particles have initial energies such that they slow to a halt after penetrating two or three inches of air. In liquid or solid matter, such as body tissue, the alpha range is much shorter (about one thousandth of an inch) because of the greater density of the matter the particles are passing through.



RADIATION EFFECTS
ON DNA MOLECULE

The knocking of electrons out of molecules can cause the molecules to be broken and changed. Some of the changes can be harmful to living tissue. For example, if the information in a DNA (genetic) molecule is changed, the functioning of a whole cell can be altered, particularly when it reproduces itself.

Beta and especially gamma radiation can penetrate far deeper into tissue than can alpha radiation. However, the density of ionization from beta and gamma radiation is much less than that from alpha particles. An alpha particle that passes through one of the big DNA molecules in a cell nucleus will probably break it in three or four places, while a fast electron from beta or the other electromagnetic gamma radiation will be likely to break it in at most one place—with a high probability of passing right through it with no hit at all. The biological harm per unit of energy absorbed from beta and gamma radiation is believed to be only one tenth or less than that of alpha particles.

Genetic molecules in tissue are frequently broken by random processes due to normal body heat and various chemicals, as well as by radiation. There are chemicals that repair single breaks, and a DNA molecule broken at one place can normally be repaired with a high probability of success. However, if it is broken in three or four places simultaneously, it may very well be put back together wrong, with possible ill effects on the cell it governs.

This ability of cells to repair themselves after minor damage from radiation lends some support to the notion that health impacts of low doses of beta and gamma radiation may become vanishingly small.

CONCLUSIONS ABOUT THE HEALTH RISKS FROM EXPOSURE TO RADON ARE DERIVED FROM 1) KNOWLEDGE ABOUT HOW RADIATION INTERACTS WITH TISSUE; 2) KNOWN EFFECTS OF HIGH DOSES OF RADIATION; AND 3) ASSUMPTIONS ABOUT HOW HIGH-DOSE HEALTH EFFECTS CAN BE EXTRAPOLATED DOWN TO LOW-DOSE EFFECTS.

There has been a very large amount of study given to the subject of the health effects of radiation. A comprehensive and up-to-date summary of knowledge on the subject is that presented in the report published by the National Academy of Sciences in 1972 and updated in 1980: *The Effects on Populations of Exposure to Low Levels of Ionizing Radiation*. The following discussion of health risks is based primarily upon the results described in that report.

Health Effects of High Radiation Doses

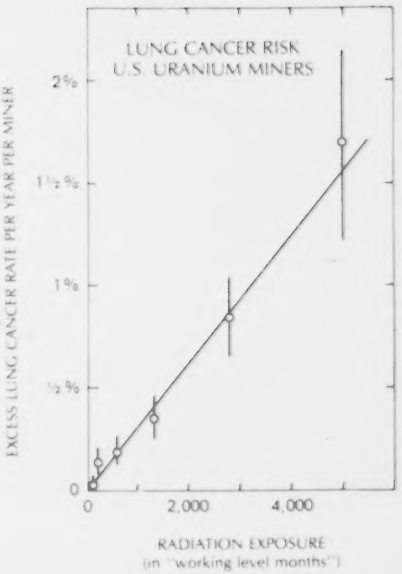
Much is known about the effects of high radiation doses on human beings. This information comes from mortality statistics of Japanese A-bomb survivors and of others subject to high doses of radiation before the health impacts were understood. These people included uranium miners in unventilated mines, workers painting watch dials with luminous paint containing radium, and persons treated with radiation therapy for non-mortal diseases.

Although there are other health effects from very high doses of radiation (i.e., those suffered by nuclear bomb victims), increased cancer risk is the only significant known health effect of radiation at levels comparable to those experienced in home environments. Moreover, scientists and people in public health agencies agree that the health risk from radon has mainly to do with airborne radon and air passages in the human body and the lungs. This is due to the constant exposure of breathing air containing radon.

There is no direct and conclusive evidence linking radon exposure in the home to increased incidence of cancer. Estimates of health risks from airborne radon have to be made on the basis of studies of people who have been exposed to high levels of radiation. The most useful of such studies appear to be those of underground miners.

Where workers in uranium and other mines have been exposed over long periods to high concentrations of airborne radon, they have had significantly high lung cancer rates. The graph was based on mortality rates of 4,000 miners who worked in improperly ventilated mines in the United States in the 1940s and 1950s. Up to 1974, there had been 135 lung cancer deaths in excess of the 16 that would have been predicted for the group with normal rates. The same relationship between lung cancer and airborne exposure has also been found in studies of workers in several different kinds of underground mines and in many countries.

The mortality rates of the miners show that there was a delay of from 10 to 25 years or more between the time of exposure and the appearance of lung cancer caused by such exposure. Miners are still dying from lung cancer caused by radiation exposure in the 1950s.



EXCESS LUNG CANCER MORTALITY AMONG URANIUM MINERS HAS BEEN PROPORTIONAL TO DEGREE OF RADIATION EXPOSURE.

The studies of uranium miners show that excess lung cancer mortality rates are proportional to radiation exposure at high doses. Similar studies have provided information on the effect of high-dose radiation on the stomach and other parts of the body.

Health Effects of Low Radiation Doses

For the purposes of this digest "high" radiation doses are those levels where a known relationship has been found between radiation exposure and increase in cancer mortality. Radiation exposure is commonly measured in "rems" and "millirems" (i.e., thousandths of rems). Conclusions from studies of miners are fairly definite for radiation exposures around 500 rems and over. Such exposure would be comparable to living in a house for 60 years with an airborne radon level of 10 pCi/L (picoCuries per Liter). Knowledge of health risks for low radiation exposure becomes more and more ambiguous at lower exposure levels, however. The lowest radiation exposure for which there is any direct evidence of excess lung cancer among miners is in the range of 40-50 rems. This exposure would be equivalent to living in a house for 20 years with an airborne radon level of 2 pCi/L.

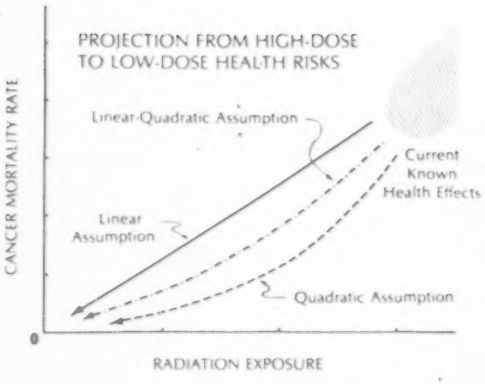
HEALTH EFFECTS (Cont.)

The projection of health risks from high radiation exposures to low exposures involves assumptions that tend to be more opinion than fact. Is the health risk from low-dose radiation simply proportional to known risks of high-dose radiation? That is, does a person exposed to one-hundredth the radiation have one-hundredth the health risk? Or is there a threshold below which radiation does not represent a health risk at all?

On the basis of experiments with animals and human cells, scientists are fairly well convinced that low-level radiation can cause cancer. But direct cause-effect information that would indicate the degree of risk is lacking now and may be for some time in the future. The problem is that incidence of cancer from other causes, such as smoking, simply overwhelms incidence from low-level radiation—making detection and statistical analysis unreliable. Indeed, the normal fluctuation of cancer rates between population groups exceeds the small increment that may be caused by low-level radiation.

The scientists are largely left, then, with the necessity of making assumptions on how the known risks at high radiation levels should be extrapolated down to low-dose levels. Current scientific opinion on this issue was recently described by Dr. Edward Webster, Professor of Radiology at the Harvard School of Medicine, and a member of the National Academy of Sciences committee working on the subject. Dr. Webster described three methods for projecting health risks from high-dose down to low-dose radiation:

1) The "linear" assumption projects health risks straight down from known risk levels to zero risk at zero exposure.
2) A "quadratic" assumption implies that the risk falls off at a substantially higher rate than the exposure.
3) A "linear-quadratic" assumption is simply the middle position between the other two.



Dr. Webster noted that the majority opinion of scientists on the National Academy of Sciences committee favors the "linear-quadratic" assumption for whole-body "gamma-type" radiation, (the kind of radiation that a worker in a nuclear power plant might be exposed to). The committee favors the linear assumption for risks from airborne (or waterborne) radon and "alpha-type" radiation.

The estimates given below of health risks from drinking waterborne radon or breathing airborne radon are based on the "linear" assumption. For reasons stated, the estimates cannot be considered exact. The uncertainties are so great that the actual risks might be double—or half—the estimated risks. Indeed, there may be synergetic health impacts from, say, exposure to airborne radon combined with smoking. Such potential impacts are completely unknown at this time.

Health Risks for People Exposed to Radon in the Home

For *drinking water*, if the linear assumption is used, UMO researchers estimate there would be an additional life-time risk of dying from stomach cancer in the neighborhood of 1% per 100,000 pCi/L. That is, if someone lived 60 years in a house with a radon level in the drinking water of 20,000 pCi/L, that person might have one chance in 500 of dying from stomach cancer resulting from the radon.

Waterborne radon levels over 100,000 pCi/L have been found in Maine, and one house had well water averaging approximately 700,000 pCi/L. The health risk of drinking water with such levels of radon would undoubtedly be considered significant enough to warrant corrective measures.

The risk of dying from lung cancer resulting from breathing *airborne* radon is estimated by UMO researchers to be 1% for each 4 pCi/L of lifetime exposure. Again, this estimate uses the linear assumption and must be considered imprecise. If the estimate is correct, a person living for 60 years in a house with an airborne radon level of 4 pCi/L would have one chance in 100 of dying from lung cancer from that cause.

An airborne radon level of 4 pCi/L is not at all unusual. UMO researchers have tested airborne radon levels in 85 homes in the state. About half of these were in granitic regions. The lowest level of airborne radon found was 0.5 pCi/L. In a few cases, airborne radon levels above 10 pCi/L were found, and in one case, the level was an extraordinary 100 pCi/L. (In uranium mines, airborne radon levels are held below 66 pCi/L.)

The significance of health risks from radon in any home is up to the individual to judge. Certainly an airborne radon level of 100 pCi/L would represent a significant health risk. But at the other end of the scale, some people could be more affected by worrying about the radon than by the radon itself. In the great majority of cases, there is no immediate urgency. Decades of exposure might involve significant risks, but generally not a few months or even a few years of exposure. (The long-term risks may be more significant in a rural state like Maine, where some people live many years in the same area and get their water from individual wells.)

PERSPECTIVE ON RISKS AND STANDARDS

As the table at right indicates, approximately 20% of deaths in the United States are currently due to cancer. About a quarter of these cancer deaths—approximately 100,000—are due to lung cancer.

There are many known causes of lung cancer besides airborne radon. Smoking is associated with 70% of lung cancer deaths. Indeed, the lung cancer rate for male smokers is 10.8 times the rate for non-smokers. And it has been found that among Japanese non-smoking women, lung cancer rates of wives of smokers are twice that of wives of non-smokers.

Other causes of lung cancer, many found in industrial settings, include: asbestos, arsenic compounds, chromate dust, nickel compounds, coal-tar fumes, isopropyl alcohol, petroleum oil mists, and products of burning coal. Wood smoke contains many of the same cancer-causing agents as tobacco smoke.

Just as radon in the home is only one of a number of indoor air pollutants, it is also only one of a number of low-level radiation sources in the environment. For most people, levels of radiation due to radon in the home are no more dangerous than a variety of other health risks. But the levels of radon in some Maine homes are producing radiation exposures far above that caused by other forms of radiation. A person living in a home with, say, 3 pCi/L of airborne radon is being exposed to around 3,000 millirems of radiation each year. And a person drinking water from a well with, say, 30,000 pCi/L in the water receives 900 millirems annually in his stomach. Such exposures, which are by no means uncommon, can be seen to be greater than the doses from all other average radiation doses.

Partly because of uncertainties about health effects of low level radiation, scientists and government agencies have been wary in setting standards for radon. Some standards for *airborne* radon are in use, however, as indicated in the table at right. The lack of a solid scientific basis for the standards is partly suggested by the way the 3 pCi/L standard was arrived at for houses built on uranium mine wastes in the United States. The threshold was apparently established, not because the risk of lung cancer was believed to disappear below the 3 pCi/L level, but because radon levels in some houses in the same region (and not built on mine wastes) were naturally that high and further reduction in the standard would involve more than removal of wastes for which the government was responsible.

For waterborne radon (i.e., radon in well water), no standard has received a consensus, at least partly because the health impacts are largely indirect and depend upon varying factors (such as ventilation and water use habits). These are discussed in the following pages.

LEADING CAUSES OF DEATH IN THE U.S. IN 1978

Heart disease	730,000	(36%)
Cancer	400,000	(20%)
Stroke	106,000	
Motor vehicle accidents	54,000	
Pneumonia	52,000	
Diabetes	34,000	
Liver cirrhosis	30,000	
Arteriosclerosis	29,000	
Suicide	27,000	
Homocide	20,000	
Emphysema	16,000	

Accidental causes (not a complete listing)

Falls	14,000
Drowning	7,000
Conflagrations in private homes	4,800
Aviation, scheduled carriers (yearly average 1976-1980)	70

AVERAGE ANNUAL RADIATION DOSES IN THE UNITED STATES

	Millirems
Routine reactor emissions	0.6
Fallout from nuclear bomb tests	4.4
Cosmic rays	28
Natural body radioisotopes	28
Natural isotopes in ground	26
Diagnostic x-rays	70

Average occupational doses for persons working with radiation sources

Commercial power reactor employee	400
Hospital radionuclide and x-ray worker	350
Dental x-ray worker	125

AIRBORNE RADON STANDARDS (FOR BUILDINGS)

Houses built on Uranium Mine Wastes in U.S.	Must be below 3 pCi/L	
Phosphate Mining Regions in Florida	4 pCi/L	Take remedial action
	2 pCi/L	Reduce to as low as reasonably feasible
Uranium Mining Regions in Canada	30 pCi/L	Take prompt remedial action
	4 pCi/L	Take remedial action
	2 pCi/L	Investigate
Sweden (maximum levels permitted)	11 pCi/L	existing buildings
	5 pCi/L	houses undergoing remodeling
	2 pCi/L	new houses
Union of Concerned Scientists	Over 5 pCi/L	remedial action indicated
	2-5 pCi/L	remedial action suggested

RADON SOURCES AND PATHWAYS

The sources of radon for any home might include:

- Groundwater as it seeps through cracks in bedrock and soil—entering the house through well water.
- Soil gas infiltrating the air of the home.
- Construction materials.

Radon in well water may be ingested into the body directly when a person drinks the water or consumes food that contains the water. Or it may affect the body indirectly through passing from the household water into the air that residents of the household breathe. As noted previously, health risks from direct consumption of well water are generally insignificant. It is the air that residents of a house breathe that provides the greatest exposure to radioactivity. And radon can get into the air through water-using activities (as well as through soil gas and construction materials).

Soil gas is the mixture of gases filling the tiny spaces and pores in the soil. Radon, being a chemically inert gas, can diffuse through cracks in the bedrock or soil particles. The radon decays and dissipates, as it moves, but it may travel far enough to infiltrate into a home and cause elevated levels of radon in the air of the home.

The kinds of soils and rocks that produce high levels of radon in the groundwater can also produce soil gas with high radon concentrations, even if groundwater is not present.

The importance of soil gas as a source of radon in the home is demonstrated by the fact that airborne radon levels have been found to be higher in basements than in other parts of the home. In the 85 homes sampled by UMO researchers, average airborne radon levels were as follows:

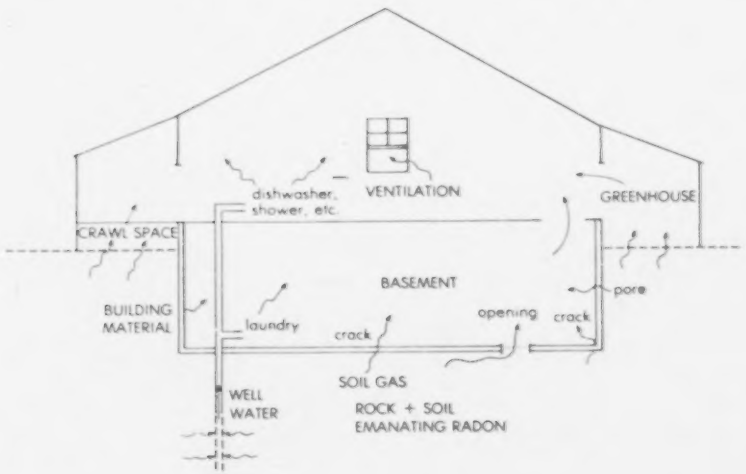
	pCi/L
Basements	6.4
Bathrooms	3.4
Kitchen/Living Rooms	3.1
Bedrooms	3.0
Outside air	0.8

These averages do not represent a pattern that is typical or uniform from house to house. Houses with dirt-floor basements are particularly exposed to soil gas, and radon levels in such homes affected the averages significantly.

Construction materials have not been found to be important sources of radon in Maine, although further studies may find that concrete may be a significant source of airborne radon in some cases.

With respect to *pathways*, the key factors affecting airborne radon levels in a home include:

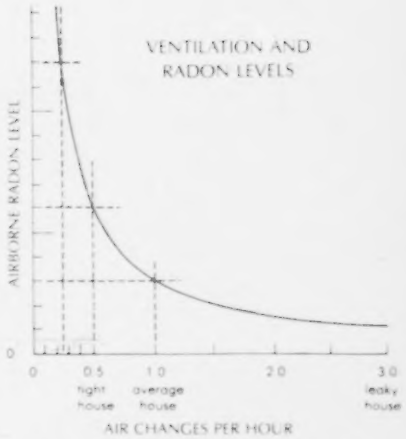
- Radon levels in the well water and water-using habits.
- Radon levels in soil gas and type of construction where house and earth meet.
- Ventilation rates of the house.



Radon in well water can be released into the air of the home in the course of various water-using activities. The rate at which radon is released from water into the air depends upon the degree to which the water is aerated. When water is agitated, the radon is released as much as eight times faster than when the water is standing and not agitated. Thus, the frequency of use of showers can affect airborne radon levels. Laundry and dishwashing machines can affect airborne radon levels too.

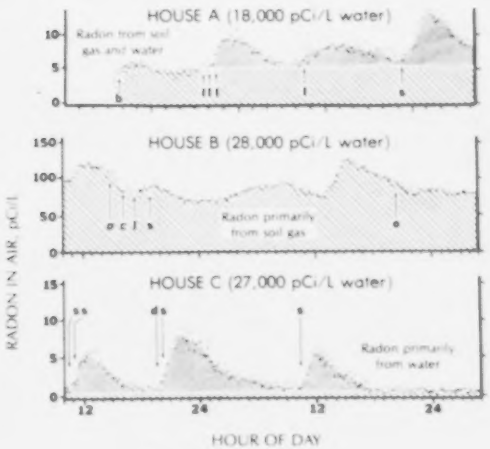
Yet, it should be noted that radon levels in well water do not have a close relationship with airborne radon levels in the home. UMO researchers have placed monitoring devices in bathrooms of a number of houses in order to determine the relationship between waterborne and airborne radon. Some relationship can be seen, but it is not a strong one. It is clear that other factors are involved.

As noted, soil gas is a significant source of radon in some homes. A small amount of such gas entering steadily into a house, if the gas contains radon at levels in the hundreds or thousands of pCi/L, may result in several pCi/L of airborne radon in the house. Such gas can enter basements through dirt floors or cracks and other openings in the basement floor and foundation walls. Thus, the type of structure may be an important factor, especially if the house is an old one. If a house or part of a house is built over a dirt-floor basement or unventilated crawl space, it may be exposed to excessive amounts of radon in soil gas.



The type of structure also affects ventilation, and ventilation is a key factor with respect to airborne radon levels, as the graph above shows. Indeed, there is a direct relationship between air change rates and airborne radon levels. For a given house, a reduction in ventilation rate, say, from one air change per hour to one-half air change per hour would double airborne radon levels.

PATTERNS OF RADON LEVELS IN THREE DIFFERENT HOMES MONITORED BY UNIVERSITY OF MAINE AT ORONO RESEARCHERS



b=bath, l=laundry, s=shower,
o=open window, c=close window,
d=dishwasher)

HOUSE A HAD A CONSTANTLY HIGH RADON LEVEL—WITH FLUCTUATIONS THAT CORRESPONDED TO PERIODS OF WATER USE. THE HOUSE WAS TIGHTLY SEALED AND HAD AN OPEN DRAIN IN THE BASEMENT (WITHOUT A TRAP). AIR IN THIS DRAIN HAD AN EXTREMELY HIGH RADON LEVEL, AND THIS AIR APPEARED TO BE DRAWN INTO THE HOUSE BY THE ACTION OF A WOOD FURNACE.

HOUSE B HAD THE HIGHEST AIRBORNE RADON LEVELS OF ANY HOUSE TESTED. (NOTE THE DIFFERENT SCALE ON THE LEFT.) THIS WAS A SOLAR HOUSE WITH ATTACHED GREENHOUSE, THE FOUNDATION OF WHICH WAS SAND AND GRAVEL OVER SOIL WITH GRANITE BEDROCK NOT FAR BELOW. RADON LEVELS WERE SO HIGH IN THIS HOUSE THAT FLUCTUATIONS DUE TO PERIODS OF WATER USE COULD NOT BE DISCERNED.

HOUSE C EXHIBITED THE CHARACTERISTICS OF A HOUSE WHERE AIRBORNE RADON CAME ALMOST ENTIRELY FROM WELL WATER. THE FLUCTUATIONS CORRESPONDED ENTIRELY TO TIMES OF WATER USE, AND RADON LEVELS DIMINISHED TO NEAR ZERO AFTER THE WATER USE.

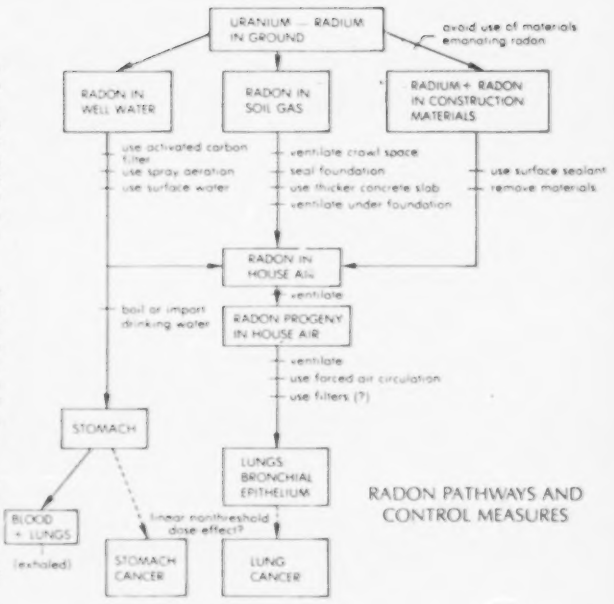
CONTROL MEASURES

The first step a homeowner can take, if he or she is concerned about radon levels in the home, is to have the well water of the home tested for radon. Such a test will not determine directly whether a health hazard exists, but it will indicate whether natural radiation levels are high and whether a potential health risk exists, particularly with respect to airborne radon. If radon levels in the well water exceed, say, the 10,000 to 15,000 pCi/L range, the homeowner should consider having the air of the house tested for radon.

If radon levels in well water are considerably above the 10,000 to 15,000 pCi/L range, the homeowner may wish to initiate certain control measures, especially those that are easy and inexpensive to take and appear likely to reduce airborne radon sources. If tests for airborne radon indicate levels above the various standards listed in the table on page 7 (lower right), the homeowner should also consider control measures that may involve some expense.

Where tests reveal high levels of airborne or waterborne radon, the homeowner will need to estimate:

- the most likely sources of the radon,
- to what extent a particular control measure might reduce radon levels, and
- whether reduced health risks from such control measures seem to justify their cost.



RADON PATHWAYS AND CONTROL MEASURES

Remove Radon from Well Water with Activated Carbon Filter or Spray Aeration System

- Activated carbon filters are available commercially. One can buy a unit that will remove 80-90% of the radon in the water from a relatively low-radon well for around $450. A unit that will reduce 90-99% of the radon from a high radon well will cost around $800. (These are 1983 prices.)
- The carbon filter unit is similar to a water softener in which the softening compound has been replaced with granular activated carbon. As does a water softener, the carbon filter unit includes an automatic periodic backflushing system to clear accumulated foreign matter from the filter.
- Carbon filters also remove uranium salts, which may be chemically toxic.
- Systems that remove radon from well water through aeration are also available commercially. These systems spray the water inside a large container, which circulates air through the spray and vents the released radon to the outdoors. The cost of an aeration unit is currently (1983) about $2,000 for a removal efficiency of 95-99%. (An improved unit—with 99% removal and somewhat lower cost—is being developed at the University of Maine at Orono.)

Remove Radon from Drinking Water Only

- If all drinking water were to be boiled, left standing open to the air for a few days, or obtained from a source with a low radon content, the radiation dose to the stomach would be virtually eliminated. Radon passes from water to air if the water is boiled or is left standing.
- This approach has the weakness that it focuses on stomach cancer risk, which tends not to be serious, and does nothing to help the problem of airborne radon.
- The benefit, in terms of reduced risk of stomach cancer death, would be on the order of one tenth of a percent less chance of such death for every 10,000 pCi/L reduction in waterborne radon (assuming lifetime consumption). With well water at a 10,000 pCi/L level, the inconvenience might not be judged to be worth the rather small reduction in cancer risk. On the other hand, the effort might be considered worth while if waterborne radon levels were very high and removal of the radon by mechanical unit (such as a filter) were considered too costly.

Ventilate House

- Tightly sealed houses, such as those with solar and energy-efficient designs, may have high levels of airborne radon from radon sources that are relatively low (because of a low air change rate).
- Low rates of air change may increase concentration of other indoor air pollutants as well as radon.
- The ventilation rate of a tight house can be increased significantly by opening a couple of windows a very small amount during the winter.
- The cost of increased ventilation for a whole house may be substantial. If a house were fairly well insulated and had ½ air change per hour, adding another ½ air change would cut airborne radon levels in half—but increase the heating costs.
- The cost could be substantially reduced by ventilating rooms having radon-generating fixtures at certain times. Radon accumulated in a bathroom when released during a shower can be largely prevented from entering the rest of the house by opening the bathroom window before opening the bathroom door—or through use of a ventilating fan.
- The heating cost can also be reduced significantly (by 50% or better) through use of an air-to-air heat exchanger. The units, which range from small window-mounted units to large floor-mounted units, can save up to 70% of the heat in the air exhausted to the outdoors. These units transfer the heat by means of thin metal or paper membranes separating the outgoing warm air from the incoming cold air. These units are reported to pay for themselves within five to ten years.
- Increasing the air-change rate for a house—either by cracking some windows or using an air-to-air heat exchanger—will reduce levels of all indoor air pollutants.

Caulk and Seal a Basement or Ventilate a Crawl Space

- Due to wind passing over a house and the pull of combustion air for heating or of ventilation air, the air pressure in a basement is normally lower than that in the soil surrounding the foundation. This pressure difference can cause large quantities of soil gas to flow through openings in the foundation.
- Major openings in foundations, like drains or sump-pump holes, are easily recognized, but small cracks and openings in the basement floor and foundation walls can be difficult to detect. A basement radon level two or more times higher than upstairs levels will suggest that such openings are present.
- Untrapped basement drains have been found to be significant sources of radon in some regions. The cost of rerouting a drain or installing a water trap (probably involving some tearing up of concrete and replacement of a few sections of pipe) will vary greatly from one house to the next.
- Epoxy paint or other polymeric coatings in multiple layers can be used to seal porous or cracked basement surfaces. However, roughnesses in the surface should first be caulked and smooth, so that there are no openings the paint cannot fill.
- The cost of sealing basement surfaces can run into thousands of dollars for large buildings. The cost of filling concrete block walls and painting a basement with epoxy would likely be under $1,000 for a typical house. Repainting might be required every ten years or so.
- Adding ventilation to a tightly-sealed crawl space (through vents) is not costly, although the resulting heat loss might be. Sheets of polyethelene, polyvinyl chloride, or polamide can be put beneath floors to reduce radon diffusion (and the infiltration of cold air). However, to be effective, there must be no openings or cracks through which the radon can bypass the plastic.

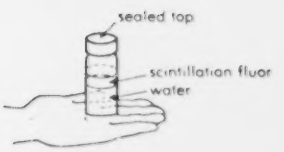
RADON TESTING

In Maine, one can have State authorities measure the radon content of *well* water for a fee by contacting:

PUBLIC HEALTH LABORATORY
DEPARTMENT OF HUMAN SERVICES
STATE HOUSE STATION 12
AUGUSTA, MAINE 04333
TELEPHONE 289-2727

The lab will send a kit containing a water sample bottle and instructions on how to add water. When the bottles are returned by mail, the Lab injects a sample of the water into a special toluene-based scintillation oil. The lab will measure the radon content and mail back the results. In other states, an inquiry to local or state health authorities will indicate whether a similar service is available.

For measuring radon levels in *air*, one can obtain "track etch" detectors. These are ordinary-looking plastic drinking cups with special strips of a plastic that will detect alpha radiation. A cup is exposed to the air in the main living space of the house for several months (preferably a year), then mailed to a testing laboratory. At the present time, the cups must be obtained and the testing done by a firm in California, but this service may soon be offered by the Maine Public Health Laboratory (see above). Persons interested in testing the radon levels of their air should write or call the Public Health Laboratory.



VIAL FOR WATERBORNE RADON MEASUREMENT

PLASTIC CUP WITH TRACK ETCH DETECTOR FOR AIRBORNE RADON MEASUREMENT

This digest is based primarily upon the report *Radon, Water, and Air Pollution: Risks and Control*, written by Conrad Weiffenbach, Assistant Professor of Physics, UMO, November, 1982. Readers who wish more complete information than that contained in this digest are referred to Dr. Weiffenbach's report.

UMO faculty members, graduate students, and others who have contributed to on-going studies of radon in Maine include:

Charles T. Hess, Professor Physics
Stephen A. Norton, Professor of Geology
Willem F. Brutsaert, Professor of Civil Engineering
Jerry D. Lowry, Associate Professor of Civil Engineering
Graduate students Robert E. Casparius, Edward G. Coombs, Jeffrey E. Brandow, Thomas Menerney, and Cindy Molk
Anne L. Hess

The studies have resulted in a number of technical publications, including:

Radon-222 in Potable Water Supplies in Maine: The Geology, Hydrology, and Physics, and Health Effects, Charles T. Hess et al., 1979, and

Investigation of Radon-222, Radium-226, and Uranium in Air and Groundwaters in Maine, Charles T. Hess et al., 1981.

Another report, designed for homeowners interested in obtaining full information on radon removal devices for well water, has recently been completed:

Removal of Radon from Water Using Granular Activated Carbon Adsorption, Jerry D. Lowry, 1983.

These various studies of radon in Maine have been supported with research funds from the UMO Land and Water Resources Center and the U.S. Department of the Interior; the Maine Department of Human Services; and the U.S. Environmental Protection Agency. People who wish to see or have copies of any of the above reports should contact the Land and Water Resources Center, 11 Coburn Hall, University of Maine at Orono, Orono, Maine 04469.

This digest was prepared by Sherman Hasbrouck of the Land and Water Resources Center, UMO, with the assistance of Charles Kittridge and Patricia Wolman, Cooperative Extension Service, UMO. Copies of the digest may be obtained either from the Land and Water Resources Center or from the Division of Health Engineering, Maine Department of Human Services, State House Station 12, Augusta, Maine 04333.

Testimony of Charles T. Hess, Ph.D.
Professor of Physics, University of Maine, Orono, Maine

Regarding "Indoor Air Quality Research Act of 1985" S.1198

Sponsored by

Mr. Mitchell, Mr. Stafford and Mr. Lautenberg
and referred to the Committee on Environment
and Public Works in the United States Senate

Senator Mitchell, and other members of the committee, I am Dr. C. T. Hess from the University of Maine. I am here to testify about the research concerning the elevated levels of radioactive radon gas in the air and water of the State of Maine and its relationship to the indoor air radon in the United States.

The radioactive chemical element radon is one step in the radioactive decay series of uranium (Page 2, Radon in Water and Air). Both uranium and radium which preceed radon are found naturally in the rock and soil. As water and air pass through the rock and soil, underground radon mixes with them and is transported into houses. When this transported radon becomes mixed with the house air, it can decay to produce radioactive daughter elements which attach to the walls of the lung and expose the lung to a radioactive dose.

Studies of radon in ground water supplies and in the air of houses using radon rich water have been in progress in Maine since 1958 and show that very high concentrations of dissolved radon are found in drilled wells in granite (up to 1,000,000 pCi/l). Correspondingly, high levels of radon are found in the

air of some Maine homes (up to 150 pCi/l). In granitic areas, some of the air concentrations exceed the OSHA standards for radon in uranium mines. In the average private well in Maine, radon has a concentration of 10,000 pCi/l of water which will produce 1.0 pCi/l in the house air. In other non-granite areas of Maine, groundwater values of 1000 pCi/l are typical (Page 3, Radon in Water and Air). Similar patterns of high water radon and high air radon in granitic areas are observed in New Hampshire, Rhode Island and Connecticut, Pennsylvania, New Jersey, New York, Minnesota, California and Virginia.

The health implications of these high levels of radon in air are based on evidence of high rates of lung cancer in uranium miners and other hard rock miners who are exposed to radon in poorly ventilated mines. (Page 5, Radon in Water and Air). The studies are most reliable for 500 rems of exposure and higher and this exposure is comparable to living in a house with 10 pCi/l in the air for 60 years. The lowest direct evidence of lung cancer is 40-50 rems of exposure which would be the same as living 20 years in a house with 2 pCi/l (Page 6, Radon in Water and Air).

Dose calculations with existing data show that indoor radon from water and soil gas produce the largest radiation dose to the public, larger than medical radiation, other natural radiation, occupational radiation or nuclear fallout. The rough estimates of long term exposure to indoor radon yields doses sufficient to

account for 5-20,000 excess lung cancers per year in the United States (Page 7, Radon in Water and Air). Respiratory cancer has several known causes, smoking, radon, asbestos, arsenic, nickle, and organic compounds such as formaldehyde which lead to 120,000 lung cancers per year. Radon ranks second after smoking as a cause of respiratory cancer. Case control studies are needed to test the estimated lung cancer risk from radon.

High levels of radon in a house are a result of radon which escapes during use of water, radon from soil gas leaking into the basement or through the slab or floor of the house, or in exceptional cases, building materials. Thus, basements and water use rooms have higher levels of radon than other rooms in a house (Page 8, Radon in Water and Air). Construction methods which prevent seepage of soil gas and use of low radon water from surface supplies such as lakes or aerated or carbon filtered ground water can prevent the introduction of radon into the house (Page 11, Radon in Water and Air). Avoidance of building materials containing high radium will avoid further radon introductions.

Sealing houses to reduce the energy loss in house air will cause a buildup of radon by a factor of 2-6 times as much, increasing the dose. Reduction of radon can be done by increasing the ventilation, by opening windows or with an air to air heat exchanger. Buildings should be designed to have adequate ventilation and energy should be conserved by insulation rather than by sealing them up.

RESEARCH NEEDS

A. NATIONWIDE FIELD STUDY OF RADON IN WATER OF PRIVATE HOMES AND SMALL UTILITIES.

B. BETTER UNDERSTANDING OF AIR-WATER RADON EXCHANGE COEFFICIENTS.

C. VALIDATION OF HOME MAILABLE WATER SAMPLING METHOD.

D. LARGE SCALE RADON MITIGATION MEASURES.

E. NATIONWIDE FIELD STUDY OF RADON IN AIR OF HOUSES.

F. NATIONWIDE FIELD STUDY OF RADON IN HOMES IN GEOLOGICALLY HIGH AREAS.

G. NATIONWIDE FIELD STUDY OF RADON IN TYPICAL SOILS.

H. CASE CONTROL STUDIES OF RADON VERSUS LUNG CANCER. (RISK OF RADON IN HIGH HOMES).

I. EXAMINE BIOLOGICAL EFFECTS OF PEAK EXPOSURES TO RADON.

J. EXAMINE TISSUE DAUGHTER CONCENTRATIONS FOR SPECIFIC NEOPLASMS.

K. EXAMINE IMMUNE SYSTEM RESPONSE TO WATER RADON REMOVAL.

L. INEXPENSIVE SHORT TERM AIR RADON DETECTOR.

M. EXAMINE EFFECT OF PARTICULATES AND HUMIDITY ON RADON DAUGHTER EXPOSURE.

AIR POLLUTION IN YOUR HOME?

AMERICAN LUNG ASSOCIATION
The Christmas Seal People ®

AIR POLLUTION IN YOUR HOME CAN BE DANGEROUS!

The average American spends at least 90 percent of his time indoors, of which 65 percent is at home.

The people who are especially susceptible are the very ones that spend the most time at home. The babies, the pregnant women, the elderly, the invalids – these become the major victims of indoor air pollution.

What's worse, like so much air pollution, many of the contaminating substances give no warning and produce vague and similar symptoms that are hard to pin down to a cause. Or produce symptoms years later, when it's even harder to discover the cause.

But thanks to research already done on industrial and outdoor air pollution, we can identify many harmful substances. We know the effects they can have and many of their sources. In many circumstances, we can take responsibility for the quality of air in our own homes.

Call your Lung Association for more information or for referral to professional help.

Take care of your lungs. They're only human.

AMERICAN LUNG ASSOCIATION
The Christmas Seal People

#1001 11 84 Published by American Lung Association

HOME AIR POLLUTION ALERT!

Produced and distributed right there? Right where you and your loved ones thought to find safety from an unhealthy environment?

Unfortunately, in many cases, the answer is yes.

Just as uncontrolled industrial processes can foul the air outside, many of industry's products, wonderful as they are, can contribute to air pollution in our homes. The process of cooking and heating our homes can also add to indoor air pollution.

And this pollution can be trapped indoors. Our need for energy, energy that was becoming increasingly scarce and expensive, encouraged us to conserve it where we could. So we made our houses air-tight, adding storm windows and insulation. We applied weather-stripping and caulking to seal cracks, and have increasingly turned to kerosene, wood and coal to help heat our homes.

As a result, researchers have found air pollution can be much greater inside the home than outside.

THE MAJOR INDOOR AIR POLLUTANTS

NITROGEN DIOXIDE (NO_2)

This gas, a major outdoor air pollutant, is also a common danger in the home. A recent study found that concentrations of nitrogen dioxide in the home can be five times the level found outdoors.

Major Sources If venting and maintenance are not adequate, gas appliances (ranges, water heaters, clothes dryers, etc.), fireplaces, and wood and coal stoves can emit troubling amounts of nitrogen dioxide.

Health Effects Nitrogen dioxide can produce eye and respiratory tract irritation and lower resistance to respiratory infection. Prolonged exposure to this gas can damage respiratory tissue and lead to chronic bronchitis.

CARBON MONOXIDE (CO)

Carbon monoxide is another hazard familiar to breathers of outdoor air. Some homes have been found to have concentrations of this gas that are above the health standard set under the Clean Air Act for one hour exposure to outdoor air.

Major Sources Carbon monoxide comes from the same indoor sources as nitrogen dioxide, and is also emitted by other combustion sources such as charcoal, gasoline engines running in attached garages or sheds, unvented kerosene heaters, and tobacco smoke.

Health Effects Carbon monoxide blocks the distribution of oxygen to the body. Depending on the amount inhaled, this gas can impede coordination, worsen cardiovascular conditions and produce fatigue, headache, confusion, nausea, and dizziness. Large amounts can cause death by suffocation.

FORMALDEHYDE (HCHO)

This pungent gas can be a real menace in the home. As of 1982, the U.S. Consumer Product Safety Commission had stacked up a record of complaints involving 3,700 people.

Major Sources Formaldehyde is found in dozens of household products. The major sources in the home are urea formaldehyde foam insulation; the resins in particleboard, fiberboard, and plywood panelling; and some carpeting, upholstery, and drapery fabric. Mobile homes, because of their extensive use of these materials and their air-tight construction, appear to have the most trouble.

Health Effects Formaldehyde gas can cause headaches, dizziness, lethargy, rashes, nausea and irritation of the eyes and upper respiratory tract. Lengthy exposure may be related to cancer.

RADON (Rn)

This radioactive gas is given off by soil or rock with trace amounts of uranium or radium, as these elements decay. Concentrations of radon inside the home can range from outdoor levels to several times as much.

Major Sources The sources of radon are homes built on or of radon containing material, water and natural gas that have passed through underground areas that contain radon, or solar heating systems that use radon emitting rock to store the heat. Granite rock and phosphate mine tailings are the most common sources of radon, though granite block buildings have not been found to have high radon levels.

Health Effects Exposure to radon gas is related to lung cancer. In fact, one study estimates 9,000 cases of lung cancer a year in this country may be linked to in home radon exposure.

ASBESTOS

The name of asbestos is given to any of a group of minerals that are fibrous, flexible, incombustible, and durable. Asbestos fibers are light and small enough to remain airborne for long periods of time, but they are rarely a problem unless the asbestos containing material is disturbed, or until it disintegrates with age.

Major Sources Many of the thousands of asbestos products are found in the home — in roofing and flooring materials, wall and pipe insulation, spackling compounds, cement, coating materials, and heat and acoustic insulation.

Health Effects Asbestos fibers are small enough to be inhaled into the lungs and are long lasting even within human tissue. As a result, asbestos can cause asbestosis (scarring of the lung tissue) and several kinds of cancer.

MICROBES & FUNGI

Viruses, bacteria, and other small disease causing forms of life are common, even inevitable, indoor air pollutants.

Major Sources Microbes and fungi can be carried indoors by people and find nourishment in poorly ventilated buildings and improperly maintained air ducts, air conditioners, humidifiers, dehumidifiers, and air cleaning filters. Plants, pets and insects are also potential sources of these pollutants.

Health Effects A host of infectious diseases may be cultivated in the circumstances just described. Legionnaires' disease is an example of such cultivated pollution. People with a particular sensitivity to even non disease causing irritants can experience reactions ranging from discomfort to severe illness.

THE SELF-EVIDENT AIR POLLUTANTS

Said to say, many people produce indoor air pollutants knowingly. And many others cooperate in that production. The sources of these pollutants make this clear.

Second Hand Smoke. In spite of the warnings on the packages, cigarette smoking continues. Second hand smoke (i.e., the smoke from someone else's cigarette) contains carbon monoxide, formaldehyde, and many other gases and particles, several of which are known to cause cancer. In a poorly ventilated space, cigarette smoke harms not only the smoker, but other occupants as well. And even second hand smoke can cause eye and respiratory tract irritation and, especially in children, reduced resistance to respiratory infections.

Household and Personal Care Products. In spite of the listing of ingredients and the warnings on the labels, people continue to use carelessly, often without bothering to read the labels, all the modern cleaning agents, personal care products, pesticides, paints, hobby products and solvents that are making our lives so easy. Potassium hydroxide, tetrachloroethylene, methylene chloride, mercury, parachlorobenzene, and lead arsenate are just a few of the multitude of potentially harmful chemicals found in these products. The average home contains some 85 aerosol products alone. At the very least, the harmful components in many of these household and personal care helpers can cause dizziness, nausea, allergic reactions, and eye, skin, and respiratory tract irritation.

If you have some of the symptoms described in this leaflet, you may be able to find out if they are caused by indoor air pollution. Just take notice. Do the symptoms appear during or after a particular activity, or when you're in a particular part of your home? Do they disappear when you go outside? Do you feel better when you open a window?

If you find that ventilation helps you, it's likely that your symptoms are triggered by something in your home.

© American Lung Association 1984

HOW TO CONTROL INDOOR AIR POLLUTION

Whether or not you have symptoms, take these precautions:

- See that your gas range is fitted with a hood fan that vents pollutants to the outside. If that's not possible, keep a window open and use an exhaust fan while cooking.
- Don't use your gas oven to heat your home.
- If the tip of your gas range burner flame is yellow or orange instead of blue, have the range adjusted.
- Have your gas or oil company regularly inspect your furnace, gas water heater, and gas clothes dryer.
- If possible, convert your gas appliances from pilot light to spark ignition.
- Make sure stoves and heaters are vented to the outside and are crack-free.
- Never cook with charcoal inside your home.
- Open the fireplace damper before lighting a fire and keep it open until the ashes are cool.
- If you use a kerosene heater, burn a low-sulfur fuel, fill the heater outside, and keep it clean and properly adjusted. Never use it in a closed room or overnight or where there are susceptible people. And never use an unvented kerosene heater.
- Reduce formaldehyde by increasing ventilation, by using an appropriate air cleaner or heat exchanger, or by covering sources of the gas with appropriate coatings and sealers.
- Check with your state or local health or environmental protection department or with the geology department of a nearby university to determine if there are sources of high radon levels in your area. If there are, call in an environmental professional to test radon levels in your home.
- Kick the cigarette habit. Refuse to allow smoking in your home. At the very least, reduce cigarette smoke by using an air cleaner or by opening a window and using an exhaust fan. Note however that many of the inexpensive "desk-top" cleaners are relatively ineffective in removing gases and small particles.
- Don't use a microwave oven if the door does not close tightly.
- Cover exposed asbestos in plastic and/or duct tape to provide an airtight seal rather than remove it. If the asbestos is flaking, be sure to use a professional to solve the problem.
- Never leave a car or mower engine running in an attached shed or garage.
- Clean air conditioners, air ducts, humidifiers, dehumidifiers, heat exchangers, and microwave ovens regularly.
- Read all the print on the container and follow the directions carefully when using aerosols and other household and personal care products. Be sure to have adequate ventilation for the product you are using.

MAINE AUDUBON SOCIETY
Gilsland Farm • 118 U.S. Route One • Falmouth, Maine 04105 • 781-2330

TESTIMONY OF
JEFFREY THALER, STAFF ATTORNEY
and
JEAN SCUDDER, ADVOCACY ASSISTANT
For The MAINE AUDUBON SOCIETY
BEFORE THE UNITED STATES SENATE
COMMITTEE ON ENVIRONMENTAL AND PUBLIC WORKS

August 5, 1985

Senator Mitchell, Maine Audubon thanks Chairman Stafford and you for inviting us to testify at your hearing on the subject of indoor air pollution. I am Jeff Thaler, the Staff Attorney and Advocacy Director for the Maine Audubon Society, which is Maine's largest environmental organization with over 10,000 members. Jean Scudder is our Advocacy specialist on gasoline contamination of air and water.

Traditionally, environmentalists and government officials have focused their attention on air and water pollution occurring outside people's homes. Only recently have studies suggested that exposure to pollutants within buildings poses a significant threat to public health. That is why last December Maine Audubon researched, drafted and introduced legislation sponsored by State Senator Mary Najarian to study the potential health impact of residential heating by wood. That is why, today, we vigorously support S. 1198, the Indoor Air Quality Research Act of 1985.

We know that a number of other witnesses today will address radon gas, and thus we will briefly concur that radon is a serious problem for

Maine and the country. Maine has a rural population that depends almost entirely upon well water drawn from groundwater reserves. Over 90% of America's rural population depends upon groundwater for all of their water needs. The presence of radon in our drinking water, wash water, and indoor air therefore represents a danger that must be responsibly and thoroughly investigated.

Maine Audubon wishes to call the Committee's attention to other, less-publicized contaminants of indoor air that also pose a clear and present danger to the public's health, requiring the immediate attention of the Environmental Protection Agency. The major contaminants we will discuss are (1) gasoline fumes, (2) residential wood stove emissions, and (3) home chemicals.

1. Gasoline Fumes

Most of us have gas cans in our garages, and many of us handle it carefully. Nonetheless, gasoline is a suspected carcinogenic and toxic compound. The American Petroleum Institute now recommends that warnings be placed on all gas pumps informing people of the potential danger of breathing gas fumes.

Far more dangerous and alarming is the now common incidence of gasoline vapors entering the home through water supplies and basements. There have been well over 200 petroleum spills into groundwater in Maine from leaking underground storage tanks. When gasoline enters a groundwater supply it is all but impossible to remove. Many people draw gas-contaminating water into their homes for years before the problem is reported and alternative water supplies are found. An April 12, 1985 issue of "Inside EPA" states that gas vapors pose four to ten times the health risk that is posed by

benzene, a constituent of gasoline which is a known carcinogen.

When gasoline-contaminated hot water is run in the home for bathing or dishwashing, concentrated vapors are released and dermally absorbed. Many of the homeowners in Maine who have experienced gasoline contamination complain of severe adverse health effects to their families and animals. Although only limited data is available about this problem there appears to be a disturbingly high death rate among animals, and one human death, from kidney tumors. Kidney and liver tumors also formed in experimental animals who were exposed to benzene.

Gasoline fumes indoors are thus definitely a topic requiring more research by EPA. Given the State estimate of 11 million gallons of petroleum products leaking into Maine's soils and water each year, this is an area pleading for attention.

2. Wood Stove Emissions

There has been a dramatic increase in the use of residential use of wood for home space heating. Since 1972, residential wood use has more than tripled in Maine. Over 46% of Maine's residences burned some wood in 1983-84. Nationally, about 15 million wood-burning stoves and fireplace inserts are in use, with over 2.2 million units sold in 1983 alone.

As with other air pollutants, the primary focus of EPA and researchers has been on the impact of wood burning emissions on outdoor air quality. The July 25, 1985 EPA proposal to issue regulations for woodstoves sold after 1987 is concerned with outdoor conditions, and ignores the seriousness of indoor hazards from the millions of existing stoves.

Woodsmoke emissions from incomplete combustion in residential stoves contain carbon monoxide, the cancer-causing benzo-a-pyrene and polycyclic organic compounds, and other chemicals with irritant and long-term effects. In Maine alone, the Department of Environmental Protection's recent inventory found annual emissions of over 7 tons of benzo-a-pyrene. Wood smoke emissions potentially threaten up to 270,000 of Maine's most susceptible citizens -- 70,000 people with chronic obstructive lung disease, 140,000 senior citizens, 34,000 children aged two or under, and 29,000 stroke and heart attack victims.

Particulate matter emitted from residential woodstoves generally are in the size range that are capable of being inhaled and deposited deep within the lungs. One of the only studies conducted to date on the indoor pollution effects from wood burning suggests that woodsmoke may be a significant factor in the occurrence of symptoms of respiratory illness in young children. The Michigan study, reported in the March 1985 issue of Pediatrics (and which we will supply to the Committee for the hearing record), involved 62 children aged 1-7. The occurrence of respiratory problems was much greater among children from homes heated by wood than among children from homes with other heat sources. Indeed, the greatest impact was in the category of severe symptoms of acute respiratory illness, including frequent coughing at night, wheezing, and coughing four or more days per week.

The Michigan findings suggest that preschool children are particularly vulnerable to indoor contamination from woodsmoke and may develop lifelong respiratory illnesses. A limited EPA survey of five Oregon homes in 1981 found that improper stove maintenance or operation can cause much higher indoor levels of particulates and hydrocarbons than the optimum. In fact,

the levels seen in one house of the carcinogen benzo-a-pyrene approximated 10 to 38 cigarettes per day for the inhabitants!

Additional research is necessary concerning the effects of indoor levels of woodsmoke emissions on human health, as well as control technologies or mitigation measures. Maine Audubon strongly urges the inclusion of residential wood burning emissions in the proposed EPA indoor air quality research program.

3. Household Chemicals

Commonly used chemicals such as laundry soil and stain removers; drycleaning fluids; and drain, toilet and cesspool cleaners, are composed of petroleum distallates and some of the most toxic organic solvents of which we know. These chemicals may re-enter the home or office place in vapor form through one's contaminated groundwater supply. Thus, people indoors may be inhaling toxics such as perchloroethylene, tetrachloroethylene, and its relatives trichloroethylene and trichloroethane. These compounds may produce a wide range of serious chronic effects in humans or test animals including cancer, mutations, neuromuscular and narcotic effects, and liver and kidney damage.

The list of common yet seriously harmful chemicals we use is long; it includes paints and thinners, chlorine and disinfectants, glues, fabrics, and construction materials. Not only must we research the toxicity levels of each of these substances on household air quality individually, but we must also assess their cumulative impacts.

Conclusion

The Maine Audubon Society believes that environmental protection must take place not just in the mountains or on our rivers, but also where we spend most of our lives -- indoors. Senator Mitchell's proposal for a research program with respect to indoor air quality is a significant first step; the program's findings will then serve as the foundation for protection of our health and that of our children.

Thank you for your consideration.

Joseph E. Brennan
Governor

State of Maine
Executive Department
OFFICE OF ENERGY RESOURCES
State House Station 53
Augusta, Maine 04333
(207) 289-3811

John M. Kerry
Director

Testimony of John M. Kerry
Director, Office of Energy Resources
Supporting a federal study of radon and other indoor air pollutants

Date of Hearing: August 5, 1985
Augusta, Maine

Maine's Office of Energy Resources strongly supports this legislation directing the federal Environmental Protection Agency to study radon and other indoor air pollutants.

As an agency which advocates the construction of tightly-built, energy-efficient structures, we are aware of the negative effects of poor indoor air quality. We go to great lengths to urge builders to install air-to-air heat exchangers to assure indoor comfort and a healthy living environment in all buildings.

However, our experience has shown that more research is needed to find solutions to the problem of providing healthy air exchange rates in well built, energy-efficient homes. Part of the problem is the toxic and other noxious products found in the modern home, and greater consumer education and awareness is needed in this area. However, good air quality and energy-efficient construction can and must go hand in hand. Research in this area is sorely needed.

Secondly, radon levels in new housing can be reduced, if not eliminated, if we improve our understanding of where radon occurs and how it can be kept out of our homes. We believe energy-efficient houses can and should be healthy, radon-free homes. The research community needs to find simple means to measure radon in existing homes and research results need to be communicated to the building industry and the public.

For these reasons, we support Senator Mitchell's legislation. Our hope is that the research produces practical results that can benefit Maine people by assuring them of healthy, energy-efficient places to live and work.

Thank you.

II

99TH CONGRESS
1ST SESSION

S. 1198

To establish in the Environmental Protection Agency a program of research on indoor air quality, and for other purposes.

IN THE SENATE OF THE UNITED STATES

MAY 23 (legislative day, APRIL 15), 1985

Mr. MITCHELL (for himself, Mr. STAFFORD, and Mr. LAUTENBERG) introduced the following bill; which was read twice and referred to the Committee on Environment and Public Works

---

A BILL

To establish in the Environmental Protection Agency a program of research on indoor air quality, and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,

SECTION 1. SHORT TITLE.

This Act may be cited as the "Indoor Air Quality Research Act of 1985".

SEC. 2. FINDINGS.

The Congress finds that—

(1) indoor air exposures account for a significant portion of total human exposures to hazardous pollutants and contaminants in the environment;

(2) various scientific studies have suggested that indoor air pollution, including exposure to naturally occurring chemical elements such as radon, may pose a significant environmental and public health risk;

(3) existing Federal indoor air quality research programs are fragmented and underfunded;

(4) the Environmental Protection Agency's research program has been hindered by a lack of clear statutory authority for conducting research on indoor air quality; and

(5) an adequate information base concerning potential indoor air quality problems does not currently exist and should be developed by the Federal Government.

SEC. 3. INDOOR AIR QUALITY RESEARCH PROGRAM.

(a) DESIGN OF PROGRAM.—The Administrator of the Environmental Protection Agency shall establish a research program with respect to indoor air quality. Such program shall be designed to—

(1) gather data and information on all aspects of indoor air quality in order to contribute to the understanding of health problems associated with the existence of air pollutants, including radon, in the indoor environment;

(2) coordinate Federal, State, local, and private research and development efforts relating to the improvement of indoor air quality; and

(3) assess appropriate Federal government actions to mitigate the environmental and health risks associated with indoor air quality problems.

(b) PROGRAM REQUIREMENTS.—The research program required under this action shall include—

(1) research and development concerning the identifications, characterization, and monitoring of the sources and levels of indoor air pollution, including radon, including research and development relating to

(A) the measurement of various pollutant concentrations and their strengths and sources,

(B) high-risk building types, and

(C) instrument for indoor air quality data collection;

(2) research relating to the effects of indoor air pollution on human health;

(3) research and development relating to control technologies or other mitigation measures to prevent or abate indoor air pollution (including the development, evaluation, and testing of individual and generic control devices and systems); and

(4) the dissemination of information to assure the public availability of the findings of the Administration pursuant to the research and development activities under this section.

(c) ADVISORY COMMITTEES.—The Administrator shall establish a committee comprised of individuals representing Federal agencies concerned with various aspects of indoor air quality and an advisory group comprised of individuals representing the scientific community, industry, and public interest organizations to assist him in carrying out the research program for indoor air quality. The Administrator shall also consult and coordinate with State and local officials and other interested parties having concerns related to such program.

(d) IMPLEMENTATION PLAN.—Not later than ninety days after the date of the enactment of this Act, the Administrator shall submit to the Congress a plan for implementation of the research program under this section. Such plan shall also be submitted to the EPA Science Advisory Board, which shall, within a reasonable period of time, submit its comments on such plan to Congress.

(e) REPORT.—

(1) Not later than two years after the date of enactment of this Act, the Administrator shall, in consultation with advisory committees and groups identified

in subsection (c), submit to the Congress a report assessing—

(A) the state of knowledge concerning the risks to human health associated with indoor air pollution, including naturally occurring chemical elements such as radon;

(B) the occurrence of indoor air pollutants, including radon, in residential, commercial, and other structures throughout the country;

(C) existing standards for indoor air pollutants, including radon, suggested by Federal or State governments or scientific organizations;

(D) the need for further research; and

(E) the potential effectiveness of possible government actions to mitigate the environmental and health risks associated with indoor air quality problems,

and making such recommendations as may be appropriate.

(2) In developing such report, the Administrator shall consult with the National Academy of Sciences on the scientific issues regarding the quality of indoor air and the risks to human health associated with indoor air pollution.

(f) CONSTRUCTION OF SECTION.—Nothing in this section shall be construed to authorize the Administrator to carry out any regulatory program or any activity other than research, development, and the related reporting, information dissemination, and coordination activities specified in this section. Nothing in this section shall be construed to limit the authority of the Administrator or of any other agency or instrumentality of the United States under any other authority of law.

(g) AUTHORIZATIONS.—There is authorized to be appropriated to carry out the activities under this section not to exceed $3,000,000 for each of the fiscal years 1986 and 1987.

○